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MANUAL FOR THE BATTERY COMMANDER

HEAVY ARTILLERY

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WAR DEPARTMENT,

WASHINGTON, *November 17, 1917.*

The following pamphlet, entitled "Manual for the Battery Commander—Heavy Artillery," is published for the information of all concerned.

[A. G. O. No. 062.11.]

BY ORDER OF THE SECRETARY OF WAR.

JOHN BIDDLE,
Major General, Acting Chief of Staff.

OFFICIAL:

H. P. McCAIN,
The Adjutant General.

FEB -4 1919

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PART I.

USE OF HEAVY ARTILLERY.

CHAPTER I.

General Discussion and Definitions.

2. By "heavy artillery" is meant artillery of medium and heavy caliber (95 mm. and above). (The caliber is said to be medium when it is equal to or 155 mm. It is heavy when it is more than 155 mm.) It is distinguished from "field artillery" (65, 75, 80, and 90 mm.) and from "trench artillery."

From the point of view of maneuvering the heavy artillery is divided into—

(1) *Heavy field artillery*, formed of batteries which can move by their own power.

(2) *Heavy position artillery*, formed of batteries which have no means of transport. These means may be furnished them, however, by the automobile service, by automobile or horse-drawn units, or railway.

In this latter category are included what is known as the "special artillery" (high-powered heavy artillery), formed of the siege matériel (370-mm. mortar) and the coast-defense and Navy material, which ordinarily can be moved only by railway (60-centimeter, or standard gauge).

For the description of the different matériel, see the "Heavy Artillery Manual," by Maj. Alvin and Capt. Andre, and the Special Drill Regulations.

CHAPTER II.

Mobility of the Heavy Artillery.

GENERAL REMARKS.

3. Certain specially organized matériel is transported only by railway (Railway Heavy Artillery), which makes their movement very easy, but renders them the slaves of the existing railway system. The other matériel moves by animal or mechanical traction, or on automobile, or (occasionally) on railway.

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On the other hand, considerable mechanical work is necessary for loading the matériel, taking it apart, into pieces which must not weigh more than 3 (or exceptionally 5) tons, and putting it back in battery.

This process is often used for the transportation of heavy position artillery. The vehicles are furnished by the Automobile Service, which brings to the battery the necessary implements for the mechanical work (gins, special blocking, rope rigging, etc.).

Note.—All the developments comprised in this question of mobility of the heavy artillery, the discipline on the march, incidents of travel, and the precautions to be taken, are covered in the course of study of the school.

Chapter III.

Power of the Heavy Artillery.

EFFECTS OF THE PROJECTILES.

SHRAPNEL OR CASE-BURSTING SHRAPNEL.

7. Shrapnel or case-bursting shrapnel is effective only against unsheltered personnel up to 2,000 m. For this type of target, especially when it is of large dimensions, shrapnel should be used, for its effects are less localized than those of shell.

The 155-mm. case-bursting shrapnel is effective even when it is not possible to regulate properly the height of burst.

SHELLS.

8. There were, before the mobilization, two general types of shell—(1) the long-steel shell, with thin walls and heavy charge of explosive, and (2) the cast-iron shell, with thick walls and small charge of explosive.

The latter was easy and inexpensive to manufacture.

Since that date the cast-iron shell, overlaid with steel, type D, has been produced. This shell is intermediate between the other two types in thickness of walls and explosive charge. It is easily manufactured and inexpensive. It has a special shape, improving the ballistic properties of the projectile. It is similar in its properties to the steel shell, and can thus take its place in many instances, especially in firing against personnel or matériel.

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FUSING.

10. The fuse is the entire apparatus which produces the detonation of the projectile. The fuse, through the instrumentality of a detonating charge of fulminate of mercury, causes a *detonator* inclosed in a *priming tube* to explode. The detonator causes the detonation of the explosive charge. The complete detonation of the latter is assured by a central tube of pulverized and rammed explosive, which penetrates the mass deeply.

We distinguish: (1) Instantaneous fuses; (2) nondelayed-action fuses, or fuses with 0 delay; (3) delayed-action fuses; (4) time fuses.

INSTANTANEOUS FUSES.

11. This designation is applicable to fuses adopted since the mobilization and in which the time required for operation is less than one-hundredth of a second. In this general class belong:

Relayed-fuse container, model 1897–1914, or model of 1915, type A, type B, type C, or No. 40-fuse container, 147-mm. cartridge.	24/31-detonating fuse, model of 1914 (red head), or detonating fuse I. A, 24/31, model 1915 (elongated fuse).
No. 30-fuse container or system of fuse containers.	Detonating fuse I. 22/31, model 1915 (red head).

The fuse of the instantaneous type I. causes detonation close to the ground and forms a sphere of compression on the ground whose crater makes a sharp indentation into the surface of the ground.

Fig. 1

Supersensitive fuses of the type I. A. when they strike the ground at a sufficient angle (greater than 15°) burst slightly above the

Fig. 2

ground and form a very slight sphere of compression of a depth of only 10 to 15 centimeters on the ground, whose crater indents the surface only to a slight degree.

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DELAY FUSES.

13. These fuses operate in five to thirty-five hundredths of a second; there are actually four durations: 5/100 (called normal delay),[1] 17/100 (called long delay), 25/100 (called a delay of 0.25 second), and 35/100 (called a delay of 0.35 second).

These are—

Relayed-fuse container, model of 1897–1914, or model of 1915, type A, type B, type C, or No. 40-fuse container for relay cartridge of 147 mm.	Detonating fuse, 24/31, model of 1899–1908 (black head, 0.05 s. delay). 24/31 detonating fuse, model of 1899–1915 (nose black, tip brass colored, 0.05 s. delay, or nose black, tip violet, 0.17 s. delay).
No. 40-fuse container, model of 1887. Detonator, model of 1887, 0.25 s. delay. No. 40-fuse container, model of 1895. Detonator, model of 1895, 0.25 s. delay.	No. 30 SM percussion shell, model of 1878–1881 (nose red), or percussion fuse, No. 30 SM, model of 1878–1881, modified in 1915 (nose black, or cylindrical head).
Head-fuse container, model of 1915, for shells of large caliber.	Head-detonating fuse, model of 1915 (tip violet, 0.25 s. delay).
Base-fuse container, model of 1915.	Base-detonating fuse, model of 1915 (tip violet, 0.25 s. delay, or green tip, 0.35 s. delay).

The delay of 0.05 s. causes the projectile to burst in the air after ricochet if the angle of fall is sufficiently small (less than 15°). The delay of 0.17 s. (0.25 s. or 0.35 s.) causes the detonation of a projectile of mean (large) caliber at the end of its course in the case of penetration into the earth.

TIME FUSES.

14. Shells intended for time-fuse fire are primed with the combination detonating fuse 24/31, model of 1916, which can operate as a time or a percussion fuse. In the latter case its action resembles that of the ordinary fuse, 24/31, model of 1899–1908.

PENETRATION OF PROJECTILES AT THE POINT OF FALL.

15. The effects produced at the point of fall by an explosive projectile depend primarily on the course it follows after contact with the ground and on the moment at which the burst takes place

[1] This is the only delay suited to ricochet fire.

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on this course. The course followed varies with several factors—the angle of fall, the residual velocity, the shape and weight of the shell, the movements of nutation and precession, and the nature of the terrain. But of all these factors the angle of fall is the most important. In accordance with the value of this angle the forms indicated below are obtained as the most probable course of the projectile.

Angle of incidence.[1]

$> 0°$ but $< 15°$. Fig. 3.

The shell ricochets after merely grazing the ground.

$> 15°$ but $< 25°$. Fig. 4. Fig. 5.

The shell, in accordance with the terminal velocity and its more or less tapering form, ricochets after making a certain subterranean course, or else remains in the ground a short distance below the surface.

$> 25°$ but $< 49°$. Fig. 6.

The shell often assumes a winding course, usually with a tendency to return to the surface.

$> 40°$. Fig. 7.

The shell generally assumes a rectilinear course and is buried to a depth which depends upon the terminal velocity, its weight, its shape, and the nature of the ground.

The factors involved are too numerous to admit of determining, by exact figures, the value of the penetration.

In the following table we have noted only a certain number of courses established with inert projectiles:

Caliber.	Terminal velocity.	Angle of incidence.	Mean penetration below the surface.	Mean horizontal course.
	Meters.	°	*Meters.*	*Meters.*
155 mm	260	30	1.6	2.5
220 mm	225	42	2.0	4.0
280 mm	350	38	3.4	4.5
	350	65	4.5	3.8
370 mm	250	35	3.0	6.5
	280	50	5.0	5.0
	290	65	6.0	2.5

[1] We may assume as the approximate value of the angle of fall 3/2 of the elevation for firing guns with full charges and 5/4 for howitzers and mortars.

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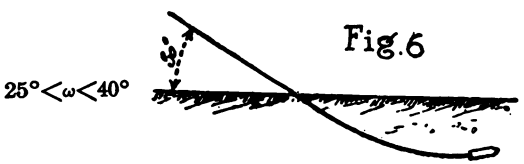
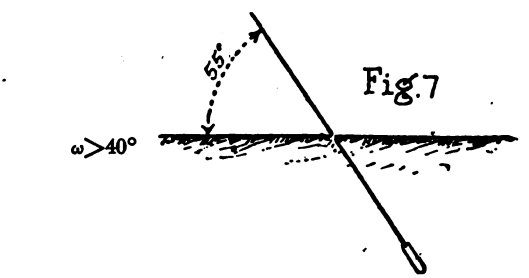
The terrain used in the experiment was of average firmness—a limestone tufa covered with a layer of clayey soil about 0.60 m. in depth.

16. From the preceding observations we need to remember merely that deep penetrations can be obtained only with the aid of projec-





tiles of large caliber fired at very great angles. With average calibers, up to 155, inclusive, projectiles fired at angles less than 20° rarely penetrate the ground more than 1 or 1½ meters. One hundred and fifty-five-mm. shells with 45° angles of incidence are necessary to penetrate a ground of average firmness to a depth of 2 meters.

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AT A DEPTH THREE OR FOUR TIMES THE LENGTH OF THE PROJECTILE.

20. Angle of incidence from 25° to 40°. Delay fuse. The volume of the earth excavated increases, but a part of it falls back, forming a conical shell crater.

AT A GREAT DEPTH.

21. Angle of incidence greater than 45°. Delay fuse. The explosive no longer has enough force to eject the earth above it. The sphere of compression forms an apparent dome at the surface, sometimes surrounded by a circular excavation. This results in a camouflet or a mine producing no exterior crater.

TABLE I.—*Clean-cut shell craters.*

22. The tables below indicate the approximate dimensions of the excavations in a soil of average consistency.

Nondelay fuse at all angles or delayed fuse at all angles of incidence less than 25°.

TABLE I.

Clean-cut craters.			
Elongated shell.	Diameter.	Depth.	Volume.
Millimeters.	*Meters.*	*Meters.*	*Cubic meters.*
120	2.5	0.9	2.6
155	3.5	1.1	6.0
220	4.5	1.4	13.3
370	6.0	2.2	36.0

Table I refers to clean-cut shell craters. It shows that even for average calibers up to 220, inclusive, the shell need not penetrate more than about 1 meter in order to throw out all excavated earth.

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in the final penetration of the projectile. Table III indicates the maximum depth which is thus obtained. The dullness of the detonation varies directly with the depth of ground at the point of burst.

In surface detonations, the cloud of smoke is voluminous and is spread over the ground. In deep detonation the smoke is less thick and mounts in a vertical column much more diaphanous, rendering the observation of the round very difficult.

TABLE III. *Maximum depth.*

Maximum depth.	
High-cap shell.	Depth attained.
Millimeters.	*Meters.*
155	3.0
220	4.5
270	6.0
370	10.0

CHAPTER IV.

Targets and Missions of the Heavy Artillery.[1]

TARGETS.

23. Guns are employed preferably against unsheltered personnel and against batteries, earthworks, and shelters susceptible of being reached by flat-trajectory fire. The angle of fall corresponding to long ranges enables us to reach sheltered targets.

Howitzers and mortars are preferably employed against earthworks and shelters which can be reached only by high-angle or vertical fire.

The 155-millimeter howitzer and the 220-millimeter mortar are advantageously used to supplement guns when we fire on targets (personnel or batteries) under cover of woods.

In exceptional cases, the 155-millimeter howitzer can be employed to make a breach in wire entanglements. (See par. 178.)

The 105-millimeter gun can be used against aerial targets.

[1] Extract from the "Employment of Heavy Artillery" (General Headquarters) and the "Employment of Artillery on the Defensive" (Center Group of Armies).

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artillery. These batteries are in position, but, save in exceptional cases, are not maintained permanently in the same emplacements. Each of them has orders covering their missions in case of a hostile attack, as well as plotting boards and firing-data books corresponding to the different positions they may be called upon to occupy. The ammunition of these batteries is divided into reserve ammunition (which is to be used only in case of attack by the enemy) and current ammunition (to meet the daily needs). The maximum expenditure is fixed, not for one day, but for a given period of time. This supply may be exceeded only when it is necessary to take advantage of a favorable opportunity or to gain some very definite result.

The reenforcement artillery consists of batteries of heavy field artillery and reserve batteries of foot artillery. Whenever it is possible to anticipate their intervention, the battery commanders inform themselves regarding the fire records of the emplacements previously prepared and reconnoiter the command posts, the observation stations, and the battery emplacements. All details are so arranged that the work of installing the communications may be undertaken as soon as the first signal is given.

ON THE DEFENSE.

27. The artillery is the principal arm for active defense, for it alone enables us to reach the main body of the enemy at any time, to hinder (and even to suppress) his offensive preparations before the offense is launched, and, in case of attack, to reestablish the equilibrium of forces rapidly, to the profit of the defense. These possibilities determine the missions.

DEMOLITION FIRE.

28. This fire is directed on: (1) The batteries, beginning with the most aggressive and the best known. The continuous demolition of the enemy's batteries is one of the principal duties of the artillery of the defense. (2) The defensive works (observation stations, command posts, blockhouses, shelters, etc.). (3) Certain formations of the enemy's troops (convoys, reliefs, fatigue parties, etc.). As these targets are usually fugitive, the fire must be launched and conducted very rapidly. The battery commanders must consequently take the initiative, and, moreover, in every battery capable of firing on such targets the important points of the terrain must be accurately registered, the battle map and firing-data book must be kept carefully up to date, and the firing data must be established in advance and constantly modified in accordance with the daily weather reports.

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tional cases (when the field artillery is too weak, when the form of the terrain prevents its effective action, etc.) the howitzers are employed in the barrage of the first line, and, in this case, their fire is launched automatically and instantaneously at the request of the infantry or on signals from the observers. The battery commander must not forget that he is responsible, and that a delay on his part, even if slight, may cause the loss of a position and the death of many infantrymen. For this reason, the guns which are not firing are laid in the direction of the barrage, and night fire is prepared so that it can be opened at any time, even under asphyxiating gas. The successive quadrant ranges and the type of fire are known to all (officers, chiefs of sections, gunners, etc.), and this information is written on the gun itself. The quadrant range of the moment is determined each time that it is necessary to do so.

The flat-trajectory guns of the heavy artillery participate in the barrage (1) by counter-battery fire on the enemy's batteries of their zone as soon as they reveal themselves, (2) by bombarding the cantonments and bivouacs in the sector of the attack, (3) by firing on the communications (communication trenches, paths, etc.), and (4) by firing on the defenses of the first line when circumstances or the form of the terrain demand it.

CONTINGENT FIRE.

34. (1) *Harassing fire.*—Its object is to embarrass the movements and supplies of the enemy. It is executed on the roads, paths, and railroads by isolated guns firing at irregular intervals, especially at the supposed hours of relief and supply, and preferably with time fuse or percussion shell, I. A. fuse.

(2) *Reprisal fire.*—Its object is to show our infantry that the artillery is watching over it and to prove to the enemy our willingness to return his fire with interest. It is directed on (*a*) the shelters opposite the positions bombarded by the enemy—a rapid howitzer fire, using more ammunition than that fired by the enemy, and opened on the initiative of the battery commander charged with the surveillance of that front; (*b*) the enemy cantonments—a volley fire, accompanied, whenever possible, by an answering fire on the enemy's batteries.

ON THE OFFENSIVE.

35. Under penalty of exposing the infantry to excessive losses, an attack succeeds only when it has been prepared and supported continuously by competent artillery.

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The ammunition allowance per gun per day[1] is:

	Rounds.
95-millimeter gun	150
105-millimeter gun	150
120-millimeter gun	120
155-millimeter gun	100
155-millimeter howitzer	120
155-millimeter rapid fire	150
220-millimeter mortar	80

The initial supply for a battery, at the beginning of the preparations for an attack, is three days' allowance, stored either in the battery magazines or in the immediate neighborhood.

36. *Demolition fire on defense works.*—This fire is generally executed by howitzers, and consists in *fire for effect on definite points* (flanking casemates, shelters for machine guns, observation stations, assembly points, etc.). These targets are located as accurately as possible by means of all sorts of data collected at the front or gathered from the statements of prisoners and compared with that given by aerial photographs and by means of a joint reconnaissance on the part of the commanders of the units of first-line infantry and the battery commanders charged with the demolition.

Only when observation is *absolutely* impossible should there be recourse to zone fire.

Demolition fire is discontinued during the night, or at least continued only in the most economical way, to prevent or hinder the enemy from repairing his works.

If 75-mm. guns are lacking the 155-mm. howitzers can be used to make the breaches in the wire entanglements. The use of these howitzers is obligatory when the entanglements are on very steep slopes and can not be reached by guns with flat trajectories and are out of range of trench guns.

37. *Fire on the enemy's artillery.*—This fire is generally executed by guns, and consists either of demolition fire or of neutralization fire. In the former case the fire must be accurate and aerial observation must be employed (terrestrial observation stations, although only rarely used for this purpose, should be sought with the greatest care, on account of the great assistance they may be able to render).

[1] This expression does not mean that the guns may (or should) fire only this amount of ammunition in a day. When necessary, and with a fresh personnel, the capacity of fire is considerably greater, and may amount to one and one-half times these figures, on condition, however, that the fire be so regulated as not to be detrimental to the preservation of the matériel nor to the accuracy of the fire.

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38. *Oblique, enfilade, or concentrated fire.*—The range and the large fields of fire of a certain number of heavy-artillery guns frequently enable us to use oblique, enfilade, or concentrated fire.

39. *Barrage fire on the supply lines.*—A certain number of guns, adjusted by aeroplane, are posted in observation on the necessary points of passage, and they execute barrage fire either on the request of the aerial observation station or systematically at irregular intervals.

40. *Fire on distant targets.*—A certain number of gun batteries (especially of the railroad heavy artillery), aided by aerial observation, fire on distant targets, such as cantonments, bivouacs, thoroughfares, etc.

OPEN WARFARE.

41. The maneuvering capacity of the heavy artillery depends on the rapidity with which the officers can estimate a situation and come to a decision, on their technical instruction, on the training of the batteries in all exercises relating to the construction of battery emplacements, on the forced maneuvers which their armament necessitates, on the installation of telephonic communications, etc.

The reconnaissance detail is pushed as far forward as possible in the column in order to be able, as soon as the order for the engagement is given, to reconnoiter and to prepare the installation of the command posts, the observation stations, the battery emplacements, the organization of fire, the liaisons, etc.

The principal mission of the gun batteries will be to master the enemy's artillery throughout the period of the battle. They will also execute long-range barrage fire on the supply lines, the assembly points, and the routes of communication.

The principal mission of the howitzers will be to destroy the enemy's defensive works.

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The circumference whose radius is r and center O intersects O A and O B at M and N. Let M P be the perpendicular to O M at M. In the similar triangles OAB and CMP

$$-\frac{F}{M P}=\frac{D}{r} \quad (1).$$

In practice, the angle m is small enough for us to assume that the perpendicular M P equals the arc M N. Equation (1) then becomes:

$$\frac{F}{\text{arc M N}}=\frac{D}{r} \quad (2)$$

or

$$F=\text{arc M N} \times \frac{D}{r}.$$

Or, expressing *m in degrees:*

$$\frac{\text{arc M N}}{2\pi r}=\frac{m^\circ}{360};\ \therefore \text{ the arc M N}=2\pi r \times \frac{m}{360};$$

In grades:

$$\frac{\text{arc M N}}{2\pi r}=\frac{m^g}{400};\ \therefore \text{ the arc M N}=2\pi r \times \frac{m}{400}.$$

In mils:

$$\frac{\text{arc M N}}{2\pi r}=\frac{m^\mu}{6{,}400};\ \therefore \text{ the arc M N}=2\pi r \times \frac{m}{6{,}400}.$$

Formula 2 therefore becomes, when substituting the value of the arc M N:

In degrees:

$$F \mp D \quad m^\circ \left(\frac{2\pi}{360}\right) \quad (3).$$

In grades: $F=D\ m^g \left(\frac{2\pi}{400}\right)$ (4).

$$\therefore F^m=D^k\ m^{dg}\ (1.57)\ (4').$$

(D^k is the distance in kilometers, m^{dg}, the value of m in decigrades,) for

$$D\ m \left(\frac{2}{400}\right)=\left(\frac{D}{1{,}000}\right)\times 10\ m \times \frac{\pi}{2}=D^k\ m^{dg}\ (1.57).$$

In mils: $F=D\ m^\mu \left(\frac{2\pi}{6{,}400}\right)$

$$\text{or, } F=\frac{D\ m^\mu}{1{,}000} \quad (5)$$

$$\text{for } \frac{2\pi}{6{,}400}=\frac{2\times 3.1416}{6{,}400}=\frac{1}{1{,}000} \text{ approximately.}$$

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Formula 5 is therefore more simple than the other two. Let it be the distance in kilometers. Formula 5 becomes:

$$F^{\text{meters}} = d^{\text{kilometers}} \times m^{\text{mils}} \quad (6)$$

$$\text{or } m^{\text{mils}} = \frac{F^{\text{meters}}}{d^{\text{kilometers}}} \quad (7).$$

Remark I.—In formula 7, assuming F=1 and d=1, we find m=1. The mil is therefore the angle at which a meter is seen at 1,000 meters.

Remark II.—1 degree is equal to $\frac{1,600}{90}$=17.77 mils, or practically 18 mils; 1 decigrade is equal to $\frac{1,600}{1,000}$=1.6 mils, or approximately 3/2 mils.

For the 155-mm. rapid-fire howitzer and the 155-mm. St. Chamond, the decigrade equals exactly 1.5 mils, since 6,000=4,000×1.5.

Remark III.—Value of the mil in minutes: 6,400 mils=360×60, or 21,600 minutes;

$\therefore$ 1 mil=$\frac{21,600}{6,400}$=3,375′. In general a mil is assumed to be 3.4′.

Remark IV.—If AB were not perpendicular to OA, it would be necessary to erect the perpendicular AB; and F would be AB′ and not AB.

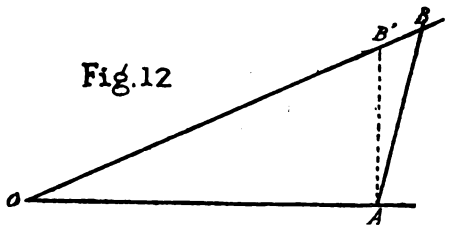

Fig. 12

46. *Angle of site.*—When the straight line AB is vertical, the length AB becomes the difference in altitude between B and A, or between B and O, for OA, being perpendicular to AB, is horizontal. The parallax then assumes the name of *angle of site* of the point B with respect to the point O.

BATTLE MAP AND $\frac{1}{10000}$ MAP PLOTTING BOARD.

47. The *battle map* (map of 1/20,000) and the 1/50,000 map (enlargement of the 1/80,000 map), squared in kilometers give us the distances between different points, the angles of site and the direc-

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tion. The plotting board is a sheet of paper stretched on a piece of board or other material, and of such dimensions as to include the whole field of fire and the observation stations drawn to a scale of 1/20,000.

I. COORDINATES.

48. The battle map is divided into 5 cm. (1 kilometer) squares. The 1/50,000 map is similarly divided into 2 cm. (1 kilometer) squares.

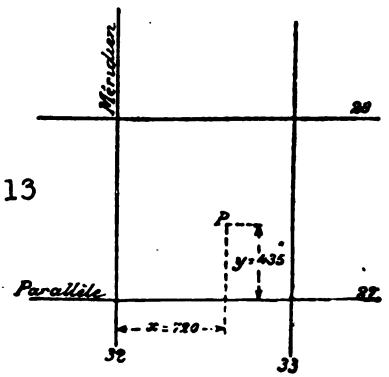
A point is determined by its coordinates, the abscissa X and the ordinate Y, which are measured by the aid of a small graduated straight-edge or the graduated right line of the opening in the protractor.

The coordinates are expressed in meters, for example:

$$P \begin{cases} X=32,720 \\ Y=27,435. \end{cases}$$

The coordinates of the *geodetic* points are given in a register attached to the battle map and issued to the batteries. They are accurate to within 2 or 3 meters.

Fig. 13



49. *Plotting a geodetic point on the plotting board.*—The use of a siege protactor for the plotting of the geodetic points and the employment of the following method is prescribed:

To plot the point M: X=5,254, Y=17,432. Pick out carefully the square ABCD in which the point M lies. Determine two points, one, x, near AB, the other, x', near CD, having the same abscissa as the point M. Draw a dotted line joining x and x'. In the same way draw a dotted line joining y and y', two points having

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The target is indicated simply by a figure of four digits formed by the digits of the kilometers and the hectometers. Example: 2,774 for P (2 being the last digit of 32, 7 the last digit of 27, and 7 and 4 the hectometers along X and Y respectively). In the case of batteries with large fields of fire, in order to avoid confusing the target with a point 10 kilometers north, south, east, or west, a letter is sometimes added to this figure to indicate that the target is in the neighborhood of some particular village, or we may even give the name of the village.

II. RANGES.

50. The guns and target are plotted on the square plotting board by their coordinates, as in the case of the battle map. The ranges

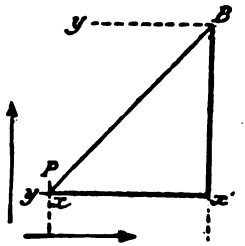

Fig. 15

are measured with a ruler whose size is appropriate to the length of the sides of the squares, or the ranges may be calculated by the formula, $d=\sqrt{(x^1-x)^2+(y^1-y)^2}$.

III. ANGULAR DEFLECTIONS.

51. We measure them in the same way on the plotting board, with a protractor having a radius of at least 15 cm.

Remark 1.—The graphic work must be done with the greatest care, using a hard pencil (No. 5) with a fine point for, since a millimeter represents 20 meters on the scale of 1/20,000, it is important not to draw heavy lines. Prick the points with a fine needle or pin held absolutely perpendicular to the plotting board.

Remark 2.—The object of this plotting on the plotting board is to avoid errors arising from the warping of the paper of the battle map. Under exceptional circumstances, it is possible to work directly on the battle map, if it is carefully attached to a level board, if we make sure that the parallels and meridians are everywhere equally distant, and if we draw, with compass and red-ink drawing-pen, concentric circles and diverging straight lines from

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After a battery emplacement has been chosen, to plot on the plotting board:

(1) The position of the guns.

(2) The aiming lines (including the staking out of the latter on the ground).

(3) The aiming points.

(4) The observation stations.

(5) The targets (designated by the battalion commander).

He must also be able to determine the altitudes of these different points.

The description and use of the topographic instruments are given in the school courses.

DETERMINATION OF THE COORDINATES OF THE DIRECTING PIECE.

55. *Definition.*—The *directing piece* is chosen by the battery commander, and is usually the right gun, unless there is some important reason to the contrary (when the aiming point can not be seen by the right gun, for example). The directing piece is so called because it is the first one aimed, and because the others are then made parallel to it. Its functions can, however, be preformed by a battery telescope or a theodolite.

The position chosen for the directing piece is marked on the ground either by its aiming apparatus, if the gun is in position, or simply by a stake. Its coordinates are found by one of the topographic methods known as three-point, traverse and interception.

56. *Makeshift methods.*—When geodetic points are lacking we may make use of objects marked on the map, crossroads, road angles, houses, or boundary corners of communes, for example. We do not use corners of woods, because they are subject to change. The roads bounding properties have not, in general, been changed since the 1/80,000-map was made, and they are easily recognizable because they mark the limits of cultivation. We must increase the number of checks as much as possible because of the local errors at certain points and the lack of precision of the double-pace method on varied ground.

DETERMINATION OF THE COORDINATES OF THE AIMING POINT, THE OBSERVATION STATIONS, AND THE TARGETS.

57. In like manner the coordinates of the necessary points are determined by the most appropriate methods.

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AIMING IN DIRECTION.

58. *Aiming apparatus.*—All guns are furnished with an apparatus for aiming in direction [1] (collimator or telescope) whose displacements are measured on a graduated circle called the main scale, while an azimuth micrometer gives the units. The main scales are graduated either continuously (with a single zero), or in two sets of half-circumferences, one set in decigrades, and the other in mils. The direction of these graduations is such that a numerical increase carries the plane of fire to the left and a diminution to the right. The only exception is for the siege goniometer, used on the jacket of the gun, but, in order that the rule may hold, it is prescribed that all guns using this goniometer will make their corrections in direction on the mirror-goniometer. (When the aiming apparatus is used away from the gun, it is used in connection with a mirror carried by the gun.)

GENERAL METHOD OF AIMING.

59. *Aiming a gun in direction* consists in displacing it until the vertical line of the sight of the gun jacket goniometer passes through the point indicated, called the *aiming point.*

Measuring the deflection of an auxiliary aiming point consists in bringing the vertical line on the point indicated, called the auxiliary aiming point, without touching the gun. This auxiliary aiming point should be very clear, easily recognized, not likely to disappear in the course of the fight, at least 50 meters away, and easily illuminated at night. It must frequently be indicated by a picket or stake. If it is not very distant (less than 2,500 meters) we must always try to pivot the gun, in making shifts in deflection, around the vertical line of its aiming apparatus. For this purpose we mark the projection of this line on the platform. After the deflection of the auxiliary aiming point is measured, the aiming is always done on this point.

60. *Mirror aiming.*—The mirror enables us to lay or re-lay the gun in deflection, and to do away with the auxiliary aiming point. Therefore it has the advantage of perfect adaption to the aiming of the guns completely sunken, or in woods, or at night, or in mist. It has the further advantage of bringing the siege goniometer under

[1] In the rapid-fire matériel, the apparatus for aiming in height and in direction are united into one, and the apparatus remains in place during the fire. Moreover, a special mechanism enables us to lay off the angle of site independently. In other matériel the mechanisms are distinct and movable (siege goniometer and level, model of 1888).

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the general rule that a numerical increase in deflection carries the fire to the left.

Assume a gun laid in the general direction of PB, with the jacket goniometer placed at P and sighted on an aiming point R. Let us place a mirror in line with the axis of the gun M and a goniometer G on an aiming rule Z Z′. The zero line of the goniometer G will always be perpendicular to Z Z′, and will lie along some such line as GX. Sight the collimator of the goniometer in the direction of GM, perpendicular to the mirror. Then move the gun through an

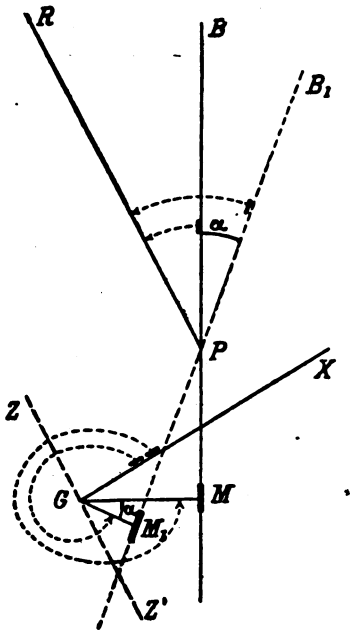

Fig.16

angle α to the right. Again sight the goniometer G, whose zero is invariable, so as to see its image in the mirror at M_1. The angle $MGM^1=\alpha$. But to pass from XGM to XGM_1 we must subtract α. Therefore, if we place the goniometer on a fixed support and note the graduation H at which we must sight it in order to bring the image of the white line of the deflector on the line of sight, the correction which we must give to n will be equal, and with contrary sign, to that which we must give to the goniometer sighted on R. Whence it follows that the sum of the angles BPR and XGM is constant.

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This sum is called the *constant of the aiming system.* It depends on the position of the aiming point R, the mirror M, and the support of the goniometer. When it is once measured from an established support, we can do away with the auxiliary aiming point. The mirror angle is obtained by subtracting from the constant of the aiming system (increased, if necessary, by 4,000) the jacket angle measured on the plotting board.

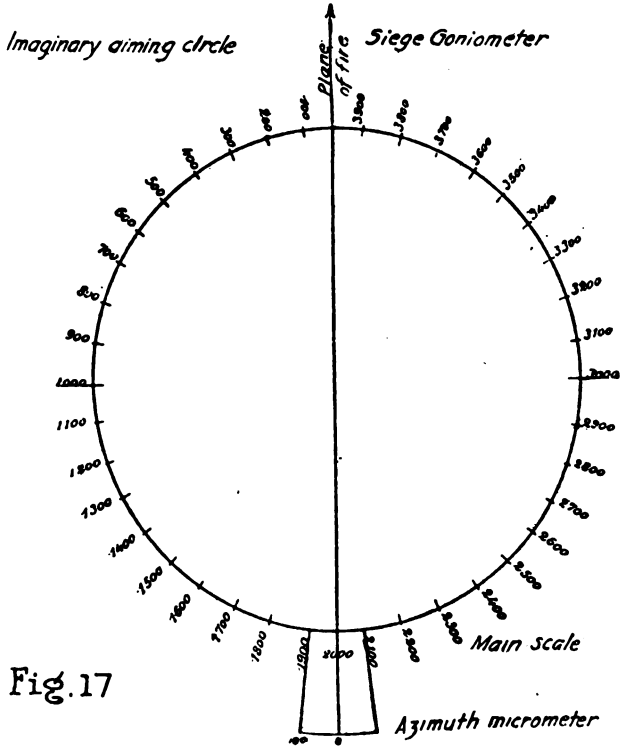

Fig. 17

Mirror aiming necessitates a daily verification of the aiming rule. The regulations are very explicit on this point.

61. *Imaginary aiming circle.*—In all aiming operations it is well to imagine the horizontal circle of the aiming apparatus, with all its graduations, as though it were fixed rigidly to the gun. In apparatus of certain models the aiming line is parallel to the plane of fire when the main sight and the azimuth micrometer both read zero,

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and in other models when the respective readings are 3,000 and zero, 1,000 and zero, etc. If the telescope or the theodolite is not graduated in the same way, we must compare the imaginary circle of the aiming apparatus to that of the telescope or of the theodolite.

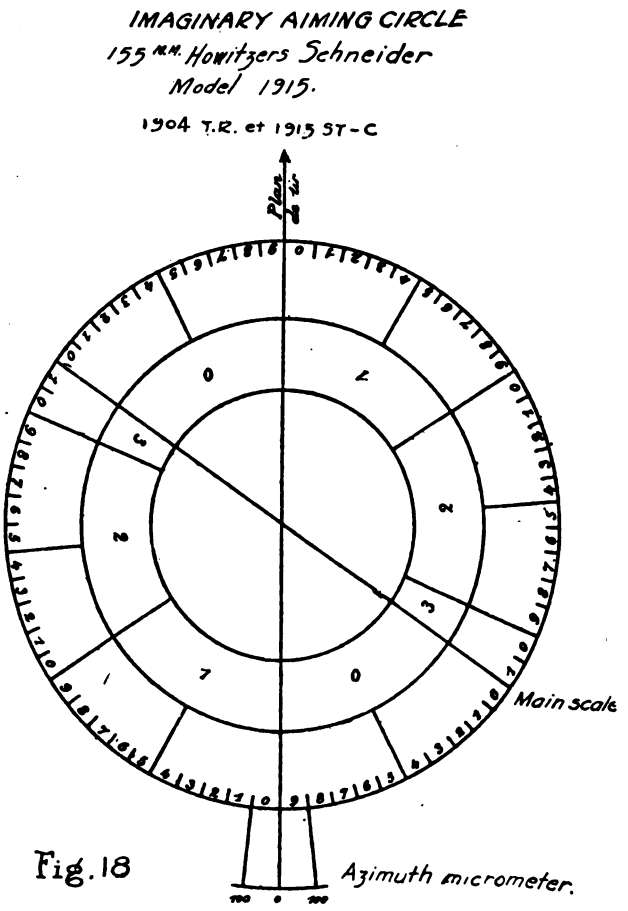

Fig. 18

TO OBTAIN PARALLEL FIRE.

62. By using (*a*) an aiming point extremely distant in any direction whatever with respect to the front of the battery (parallax zero); (*b*) any aiming point R, making the correction for parallax, if neces-

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the parallel fire of the guns. Then the index is unclamped and set opposite the graduation which is diametrically opposite zero.[1] The index is then clamped, and the telescope is sighted on the vertical axis of the aiming apparatus. Read the graduation obtained and lay it off on the apparatus of the gun. Aim the gun by sighting on the frame of the telescope, making it pivot around its aiming apparatus. Repeat the operation if, in laying, the axis of the aiming apparatus has been displaced more than one division of the micrometer of the telescope.

Remark.—When the telescope is set up in rear, do not, in this adjustment, use the aiming prism or mirror, since its angle may vary in the different guns.

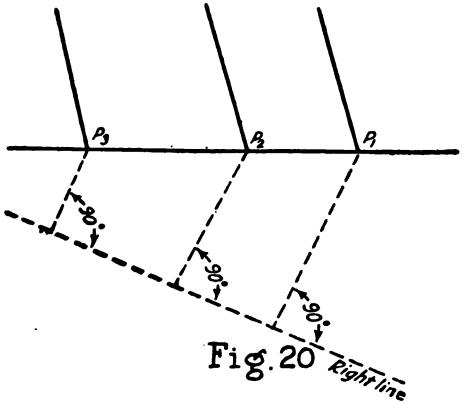

Fig. 20

64. *Aiming by means of a right line in rear of the battery.*—This method is useful in connection with batteries in woods, when the pieces can not see each other.[2] Establish a right line behind the batteries. If necessary, stakes or other means will suffice to mark out this line. Move along this line a surveyor's square (or other optical instrument which gives a right angle), in such a way as to sight on the vertical axis of the aiming apparatus of each gun successively along a perpendicular to the line. Lay each piece in succession with the same angle on the vertical axis of the instrument employed. Take the same precautions as in reciprocal aiming,

[1] If the horizontal circle of the theodolite is graduated in semicircumferences, the index must be brought to one of the zeros.

[2] In this case each gun can be aimed by placing the orienting theodolite successively near each piece; but this method is not very exact.

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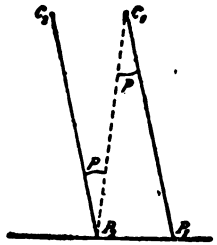
fourth by triple this angle, by the command: "Open (close) by so much."

(c) *To shift the sheaf.*—The sheaf is shifted as a whole by the command: "Add (subtract) so much."

Remark.—The angle between the points of fall, in parallel fire, as seen from the battery, evidently varies with the range. Its measure is the parallax at a point of fall of the interval between the pieces (if the intervals are equal—hence the advantage of equal intervals). It therefore varies with the obliquity of the fire to the

Fig. 21



battery front. To make the pieces converge on one point, the command is "Open (close) by so much"—the parallax at the point with respect to the interval between the pieces.

OBSERVATION.

67. *A battery is said to be in observation when the pieces are parallel and the directing piece is laid on a visible or invisible point about the middle of the field of fire, in the region of the probable targets.* This point is called the registration point.[1]

The registration deflection [2] of each piece is recorded by the gunner and the chief of section at the command, "Record the deflection."

If the guns are provided with aiming mirrors, as soon as the battery has been posted in observation the pieces are laid by the mirrors, and the registration deflection is the deflection which is obtained in this way.

The registration angles on the gun jacket, the registration deflections, and the constant of the aiming system are noted by the gunner.

[1] It may be advantageous, for batteries with large fields of fire to have several registration points, called registration point No. 1, registration point No. 2, etc.

[2] The registration deflection is therefore the angle between the aiming point and the registration point. It does not include the correction for drift.

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Time of flight.—Time, in seconds, that the projectile requires to go from the origin to the point of fall.

Angle of fall.—Angle between the tangent to the trajectory at the point of fall and the horizontal plane.

Terminal velocity.—Velocity of the projectile at the point of fall.

These definitions are regulation and correspond to the range tables.

In practice, however, we call the point of fall that point where the trajectory strikes the ground. This point is not necessarily in the horizontal plane of the piece.

We also call the angle of incidence that angle between the trajectory at the point of fall and the ground or the surface of the target.

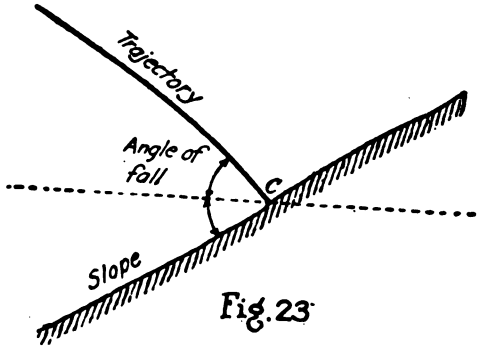

Fig. 23

To obtain this angle, subtract the slope of the ground near the targets from the angle of fall given by the range tables if the ground slopes down in the direction of fire, and add these two latter angles if the ground slopes the other way.

FORM OF TRAJECTORY—DIFFERENT KINDS OF FIRE.

71. The projectile deviates more and more from the line of fire under the influence of gravity and the resistance of the air. In vacuo, the trajectory is a simple curve, called parabola, symmetrical with respect to the maximum ordinate. The angle of fall equals the angle of elevation, and the terminal velocity equals the initial velocity.

INFLUENCE OF THE RESISTANCE OF THE AIR.

72. The resistance of the air retards the projectile constantly. The trajectory becomes a curve no longer symmetrical, whose angle of fall is greater than its angle of elevation and whose terminal velocity is less than its initial velocity. The descending branch is shorter

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and more curved than the ascending branch, in spite of the fact that the projectile takes more time to cover it.

Moreover, as a result of their rotation, projectiles leave the plane of fire and deviate more and more in the direction of the rotating movement of their upper surfaces; that is, to the left for guns rifled to the left (95 mm. and several Navy guns), to the right for guns rifled to the right (the great majority of heavy artillery guns).

The distance CD which the projectile deviates from the plane of fire is called *the drift*, and the angle CPD is called *the angle of drift*.

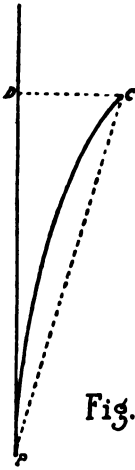

Fig. 24

Very heavy projectiles of appropriate form[1] and of low velocity are, comparatively speaking, delayed but little by the resistance of the air. Their trajectories differ but little from that in vacuo, and are influenced but slightly by atmospheric variations. But the high-velocity projectiles, especially those of small and average caliber, are delayed considerably, and their trajectories are very much affected by variations in the resistance of the air.

INFLUENCE OF THE QUADRANT ELEVATION.

73. When the quadrant elevation increases, beginning at 0 (the initial velocity remaining constant), the maximum ordinate, the angle of fall, and the time of flight increase. The range increases up to a maximum corresponding to an angle somewhat less than 45°; then it diminishes until it reaches 0 for an angle of fire about

---

[1] The ballistic coefficient of a projectile shows to what extent it will be retarded by the resistance of the air.

Value of the ballistic coefficient $C=\frac{p}{i\,a^2}$ { p being the weight of the projectile, a the caliber, i the form index.

Examples:

95 large-capacity shell	C=1.6		
Shell D	C=2.3		
100 rapid-fire cast-iron shell	C=1.9		
Steel, 1915	C=2.2		
105 shell D (steel), 1914	C=2.6		
120 large-capacity shell	C=1.86	Shell D	C=2.2
155 large-capacity shell	C=2.3	Shell D	C=3.0
220 shell, model of 1909	C=2.8	Shell, P, ogival, 1915	C=4.5
240 rapid-fire ogival cast-iron shell	C=3.8		
305	C=7		

Note the favorable influence of the form of the D shells.

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angle of site, with its sign, must be added, and a correction, called the *complementary correction for site*, must be made. This correction has the same sign as the angle of site. It is zero (or considered to be zero) when the quadrant elevation is less than 10°, or the angle of site less than 10 mils (30 minutes).

The tables give the complementary correction for site only in plunging fire. In vertical fire the correction for site is made on the range in the following manner:

Correct the range for half the difference in altitude between the target and the gun, this correction being added or subtracted, according as the target is higher or lower than the gun.[1]

THE PHENOMENON OF DISPERSION.

(Paragraphs 76 to 86 omitted. See paragraphs 24 to 34, inclusive, "Manual of the Battery Commander, Field Artillery."

PRACTICAL RANGE TABLES.

87. For the same targets and the same value of the resistance of the air, the trajectory depends only on the initial velocity and the quadrant elevation.

The range tables assume that the wind is zero, that the temperature is 15°, the pressure 750, and the hygrometric condition ½. The weight of the projectile, the strength of the powder, and the condition of the gun are assumed to be those used in establishing the tables. Under these conditions the tables give, for different initial velocities (different charges), the elements of the trajectory corresponding to a certain quadrant elevation.

The *practical range tables* give, per charge, the quadrant elevation, the drift, and the fourchette [2] (Table VI) for every range. The old tables give the correction for the jacket goniometer, the new tables for the mirror goniometer. The other elements are to be found only in the *range tables*, properly so termed, commonly called *complete tables*.

New practical tables have been made, giving, in addition to the quadrant elevation, the drift and the fourchette, the maximum ordinate, the time of flight, the correction in direction for a lateral wind of 10 meters, the angle of fall, and the theoretical probable error in range and direction.

If, instead of fixing the initial velocity and range, we fix two other elements, for example, the angle of fall and the range, the trajectory is equally determined.

---

[1] Since the angles of fall in vertical fire are about 60°, $Cm = \left(\frac{Mm}{2}\right)$.

[2] One fourchette=4 probable errors in range.

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We thus find in the tables (Table IV) the initial velocity (charge) corresponding to a given angle of fall and range.

Finally, we find in the tables various useful information as to—the gun, the projectiles, and the charges; the parallax of a front of 1 meter at different ranges; the corrections in direction due to the wind; the complementary correction for site; the correction for the fuse, due to altitude; the corrections for range, due to wind, temperature, atmospheric pressure, and variations in the initial velocity (New tables). There are even found in certain tables corrections due to the inclination of the axle and the variation of the ballistic coefficient.

Remark.—The descending branch of the trajectory can be constructed with a certain degree of approximation, and the elements at a point can be determined in the following manner: Subtract from the quadrant elevation successively n, $2\,n$, etc., degrees, and find the elements of the trajectory corresponding to this new quadrant elevation.

NOTATIONS.

88. The following notations are employed:

$d\,V_0$=variation of initial velocity; that is, the difference, positive or negative, between the initial velocity V_0 of the tables and the velocity V due to the conditions at that moment.

$d\,\alpha$=variation in the quadrant elevation.

$d\,p$=variation in weight of a litre of air.

$d\,P$=variation in range.

$d\,W_1$ or $d\,W_x$=longitudinal component of the wind.

$d\,W_2$ =transverse or lateral component of the wind.

$d\,c$=variation in the ballistic coefficient.

θ=the inclination of the axle.

BALLISTIC CORRECTIONS.

89. The range tables give the elements for a projectile of definite weight fired with a given initial velocity. But, for reasons of manufacture, not all projectiles have the same weight, and the initial velocities vary with the weight of the projectile, the quality and temperature of the powder. There are also other causes which further modify the initial velocity and the trajectory.

DISTURBING CAUSES ARISING FROM THE PROJECTILE.

90. *Weight of the projectile.*—Every projectile is marked with either the figure indicating its weight or with letters showing that its weight is included within certain limits. The parks should, as far as possible, send out projectiles in lots of the same weight.

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The influence of the weight of the projectile is an involved question, for an increase in weight implies a decrease in initial velocity (diminution in range) and an increase in the ballistic coefficient (increase in range).

This influence is therefore weak, especially for heavy projectiles, whose variations are but a slight fraction of the total weight.[1] It is usually sufficient to apportion the projectiles into lots in such a manner as to be able to execute fire with projectiles of the same weight. But the new tables give the variation in range for a difference of 0.1 kg. in weight.

INFLUENCE OF THE RAMMING.

91. The ramming of the projectile must be uniform to maintain a constant charge density.

EFFECT OF LUBRICATION.

92. In all fire with heavy charges the tubes are oiled at least every four rounds.

When firing with diminished charges, lubricating the projectiles (using an abundant layer of lubricant in front of the belts), will generally suffice for the lubrication of the tubes.

The influence of lubrication may be effective in one of two ways: Lubrication lessens passive resistances, which tends to increase the initial velocity. It also diminishes the friction, which tends to diminish the compression and, consequently, the velocity.

Lubricating should therefore be done uniformly, special care being taken, whenever possible, to lubricate the tube at every round when the charges are heavy.

INFLUENCE OF THE CONDITION OF THE OUTER SURFACE.

93. Every difference in the condition of the surface involves a difference in the resistance of the air.

[1] Examples: (*a*) The shell B, 155-mm. gun, weighs 42.9 kg. and the shell F. A. (cast iron, overlaid with steel), 43.75 kg.; difference, 850 gr. The cast-iron shell overlaid with steel, marked with a black ring, may be fired with the charge 000. At about 8,000 meters its range is the same; at 12,000 meters the range of the cast-iron shell overlaid with steel (the heaviest type), is greater by 30 m.

(*b*) The 155-elongated shell, 1887-1894, weighs 43.7 kg., and the shell, model of 1890, 43 kg. At 6,000 meters, the range of the shell, model of 1890 (the lightest), is 70 m. more.

(*c*) The correction at 1,200 meters does not amount to 40 m. for a variation of 200 gr. of weight for the 105-mm. projectile.

Note that for heavy projectiles fired with low velocity, which are consequently relatively less retarded by the air, the increase in the weight of the projectile produces, in a general way, a decrease in range. Example: For an increase of 1 kg. in the weight of the 370-mm. projectile, weighing 500 kg., there is a corresponding diminution of 5 m. in range. The corresponding correction can therefore be made.

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INFLUENCE OF THE FORM OF THE FUSE.

94. The resistance of the air varies with the form of the fuse.

The new tables make a distinction between the shell primed with instantaneous (I.) fuse and shell primed with (I. A.) supersensitive fuse. (The variation in weight being slight, the initial velocity remains practically the same for heavy projectiles. The I. A. fuse weighs about 235 gr. more than the I. fuse.)

First example: The I. A. fuse diminishes the range of the 105-mm. shell by—

32 meters at 6,000 meters.
230 meters at 9,000 meters.
680 meters at 13,000 meters.

Second example: Cast-iron shell overlaid with steel for 155-howitzer, Schneider model of 1915:

	Quadrant elevation.	Drift.	Probable error in range.
	° ′		*Meters.*
At 11,500 meters, with instantaneous fuse	36 31	24	49.4
With supersensitive fuse	38 45	25	60.2

DISTURBING CAUSES ARISING FROM THE POWDER.

95. These are much the most important. Powder is a material whose manufacture is delicate; it is constantly being modified by the influence of time, heat, and humidity.

96. *Lot number of manufacture.*—As far as possible, the parks should send out the powder in similar lots. The batteries should be assured each lot is of good and similar conditions of preservation. Fire should be executed with the same lot. The separation into lots is done in accordance with the manufacture of the powder; there is no need to retain the marks on the bags, but, among the marks relating to the charge, the one indicating the lot number of manufacture [1] and the date should be kept.

Besides, if the powder charge varies with the lot of powder employed (charge used), a mark (theoretical charge on the tables or initial velocity realized) indicates the ballistic conditions.

[1] Brands of powder:

S M=St. Medard.
R P=Le Ripault.
P B=Pont de Buis.
T E=Toulouse.
S L=Sevran Livry.
B=Le Bouchet.

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In case there is the least doubt, there should be no hesitancy about weighing the cartridges. Every heavy battery has a scale, which should be considered a valuable part of the equipment.

97. *Temperature.*—The temperature *of the powder*, at discharge, has an influence on the initial velocity represented by—

$$\frac{dV_0}{V_0}=\frac{t-15}{1{,}000}$$

t being the temperature of the powder, that is, either the temperature of the sunken shelter, if the powder chest has just been taken out of it, or else the exterior temperature, if the chest has been exposed to the air for a long time. Evidently it will be difficult to determine between these two extreme cases.

Table VI of the new range tables enables us to calculate the variation in range corresponding to V_0.

Important recommendation.—Never leave a cartridge in a gun heated by fire or the sun. Never leave a metal chest in the sun. With the black metallic chest, the elevation of temperature is such that the powder emits gases which swell the chest and escape from the aperture.

98. *Humidity.*—The humidity of the powder reduces its initial velocity.

Important recommendations.—Open and close the chests without injuring the air-tight joint. Keep the uncased wooden chests in dry shelters, and use them first.

99. *The influence of bags of antiflash powder.*—The use of antiflash powder bags may be considered as having no effect upon the initial velocity. But the suppression of the flash has no advantage except by night and for batteries not well protected. Since they cause serious choking of the gun, the bore must be cleaned frequently. If there are no bags, lubricate the bore or even coat the muzzle with green soap. It will be remembered that 10 per cent of the 100-mm. cases contain antiflash disks, and that all the 105-mm. cases are provided with them.

ATMOSPHERIC CORRECTIONS.

100. The range tables give the elements with no wind and for a density of air of 1.208 gr. This density varies with the temperature, the pressure, and the hygrometric conditions. The normal density of 1.208 corresponds at 15° to 750 mm., hygrometric condition 1/2.

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Several times a day (at least three times) the meteorological stations give the velocity and direction of the wind at different altitudes (every 500 meters), the temperature, the reduced pressure at sea level, and the hygrometric condition.

Usually the balloon connected with a battalion or a command can furnish this information.

This information is compiled under the name of "*soundings at such an hour.*"

Example of sounding:

[September 28. Sounding at 2.15 p. m.]

	Direction.	Velocity.
Wind at earth's surface	..	4
Wind at 500 meters	27	8
Wind at 800 meters	28	9
Wind at 1,400 meters	30	11
Wind at 2,000 meters	29	10
Overhead		Clouds.
Pressure at the station		736
Pressure at sea level		747
Temperature		14°
Hygrometer		0.75

NOTE.—The batteries are provided with a thermometer and a barometer.

101. *Wind.*—The velocity and direction of the wind usually vary with the altitude. It is known that the projectile remains longest in layer No. 5. Therefore, we use the velocity and direction of the wind in the neighborhood of four-fifths of the maximum ordinate of the trajectory under consideration.[1]

[1] In unsettled weather the sounding shows that the atmosphere is divided into layers having different velocities and different directions. In a fire which must be executed without control it is therefore not sufficient to assume the wind at four-fifths of the trajectory. The following method must be employed: If we divide SH (maximum ordinate) into two parts, it is approximately certain that the projectile remains in the upper zone twice as long as in the lower. Under these conditions we must estimate, after the sounding has been made, the mean wind in each of the two zones. Represent them by sectors giving to the upper wind the coefficient 2, to the lower the coefficient 1, and deduce from them the resultant which represents the action of the wind upon the projectile (see figure).

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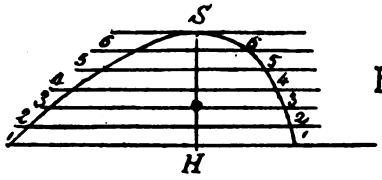


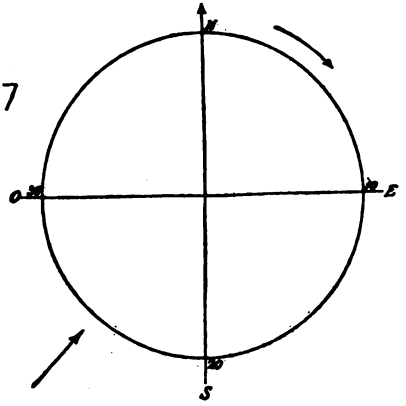
Fig. 26

$$OH=2OH'$$

Therefore—

$$OR=\frac{OR'}{3}$$

Fig. 27



The direction (that is the direction from which the wind is blowing) is given by a figure included between 0 and 40; that is, in tenths of grades (decagrades).

0—wind coming from the magnetic north.
10—wind coming from the east.
20—wind coming from the south.
30—wind coming from the west.

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The force of the wind is indicated in meters per second.

Example: Direction 27, velocity 8, means wind of 8 meters coming from west-south-west.

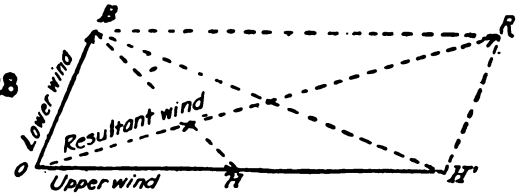

Fig. 28

102. *Value of the corrections.*—The new table give the corrections to be made for a longitudinal wind of 10 meters and a transverse wind of 10 meters.

The old tables give only the correction in direction for a strong lateral wind (10 meters) (table II).

When new tables are not at hand, consult the appendix to the range tables. "*Corrections to be made to the calculations for range*" (*Feb. 2, 1916*).

Finally, when even these appendixes are lacking, use for the range the following formulas:

Modification to be made in the range per meter of longitudinal velocity of the wind:

120-mm. gun=(4 K−7) meters.

155-mm. gun=(4 K−10).

155-mm. howitzer=0.375 K^2.

220-mm.=$\begin{cases} 0.4\ K^2. \\ \text{Elongated shell, 1900, Charge 00:}=\dfrac{K^2}{4} \end{cases}$

270 mm.=$\dfrac{K^2}{4}$.

K being the range in kilometers.

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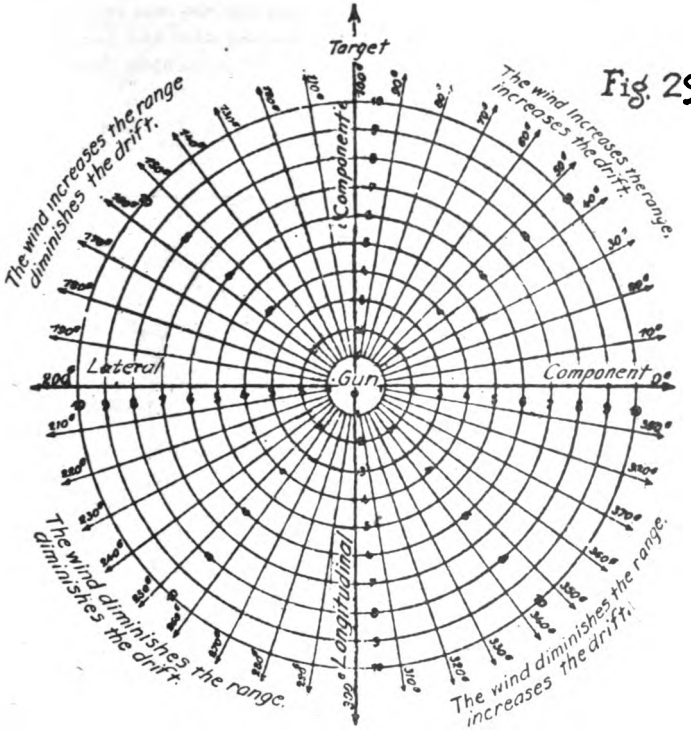
103. *Determination of the components.*—To find, without calculations, the components of the wind along the line of fire and the perpendicular direction, it is convenient to use a wind diagram.



Graphical sketch for the determination of the components of the velocity of the wind, parallel to the plane of fire (longitudinal component) and perpendicular to the plane of fire (lateral component).

For a definite direction of the wind, the corresponding arrow point indicates the point toward which it is blowing.

The diagram given for this purpose by the new range tables, and reproduced above, is especially useful, noting, however, that it takes into account the direction in which the wind is going, not that from which it is coming. It consists of 10 concentric circles, graduated

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into decigrades, each corresponding to the velocity of the wind from 0 to 10 meters, given by the soundings. A simple projection on the horizontal and vertical axes is sufficient to give the lateral and longitudinal components of the wind.

It is also very convenient to divide this diagram into two, transferring to a *cardboard disk* the two rectangular axes and the cross-sectioning which gives the projections of the radii upon these two

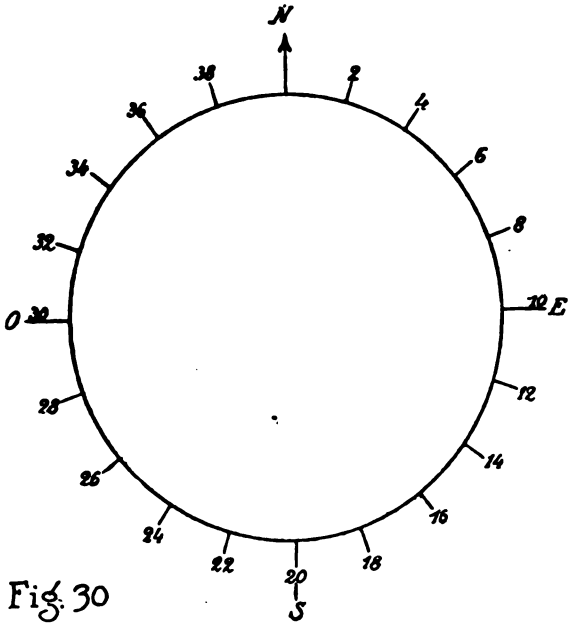

Fig. 30

axes, and to a *cardboard plate* the graduations in decagrades, starting from the north, as well as a second graduation in decigrades (or mils) beginning with the direction of the observation.

If one of the cardinal points happens to lie on the chosen line of observation (this line of observation may, however, be imaginary) the wind diagram thus established will serve for all positions of the battery, and there will be no need to use the protractor.

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Finally, when the means are at hand, the corrections from the tables for the projectile and charge under consideration may even be transferred to the disk itself. In this case we need as many disks

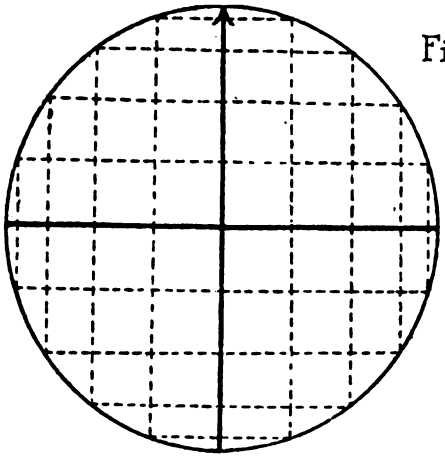

Fig. 31

as there are projectiles and charges, but the diagram, being always the same, may be multigraphed.

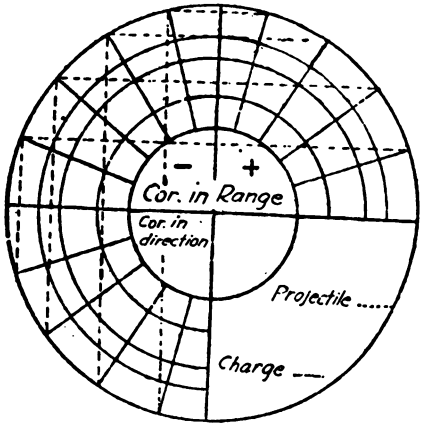

Fig. 32

Note, however, that for the same variation in range, the angle corrections to be added are, at long ranges, larger than those to be subtracted (inversely in vertical fire). Two quadrants are therefore

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105. *Hygrometric conditions.*—The variations for hygrometric conditions have but slight influence, and may in practice be neglected.

Relative value of the soundings.—A sounding should always indicate the hour at which it was taken, for atmospheric variations are often rapid. In unsettled weather, or when the last sounding is several hours old, it is well, while waiting for a new sounding, to consider the information given as obsolete, and to correct it by estimation; for example, by observing the direction of the clouds, of kite ballons, and of weather vanes. Do not hesitate for an important fire to ask for a special sounding.

106. *Utility of atmospheric corrections.*—These corrections are extremely useful. If calculated with care, in accordance with a recent sounding, they permit us—

(1) To begin an adjustment with aircraft in the neighborhood of the target, even without previous adjustment upon an auxiliary target;

(2) To utilize the results of former adjustments (see firing data book);

(3) To open fire in case of need on a target without adjustment and on an area reduced by half;

(4) To know that the targets at the limit of range can be reached only under certain conditions;

(5) To anticipate the corrections necessary to avoid hitting our own troops, especially in barrage fire; and

(6) In general, to increase effectiveness and reduce expenditure.

Whenever corrections can be made under the conditions indicated they must be made, even if the result is less than one probable error, for the best conditions must be attained, i. e., the center of impact must be brought as close as possible to the target.

COMPARISON BETWEEN ATMOSPHERIC AND BALLISTIC CORRECTIONS.

107. It is therefore evident that—

(1) The atmospheric corrections can be made with great exactness if the soundings are sufficiently frequent and if they are immediately communicated to the batteries.

(2) On the other hand, the ballistic corrections are found with difficulty, especially those due to the powder, which are by far the most important.

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(*b*) Protected by an epaulment.

All calibers: Cast-iron shell overlaid with steel, or steel shell (preferably), some with nondelayed or 0 delay fuses, others with instantaneous fuses, if the angle of incidence is $< 30°$.

Cast-iron shell overlaid with steel or steel shell (preferably), instantaneous fuse, if the angle of incidence is $>$ or $=30°$.

113. *Wire entanglements.*—

All calibers $<$ 220 millimeters: Steel shell or cast iron overlaid with steel, instantaneous fuse. (According to trials made in the Course of Instruction, at mean ranges (3,500 meters), with well-adjusted fire, 75 rounds of 155 millimeters enable us to open a passage from 5 to 10 meters in width in an entanglement 20 meters deep located on a horizontal terrain. At 6,000 meters, the expenditure of ammunition would be almost double. When the entanglement is on an ascending slope, the expenditure of ammunition can be diminished; on the other hand, it must be increased when the entanglement is on a descending slope.)

114. *Trenches and parapets.*—

All calibers: Cast-iron shells overlaid with steel, or steel shells; fuse nondelay or 0 delay, no matter what may be the angle of incidence, and steel shells with delayed fuse when the angle of incidence is $< 30°$.

115. *Woods, abatis, etc.*—

All calibers: Cast-iron shell overlaid with steel or steel shell; all fuses except the long delay (0.17 or 0.25 sec.).

116. *Railways.*—

Caliber of 105 millimeters and above: Steel shells; nondelay or delay fuses (angle of incidence $< 30°$).

117. *Villages.*—

All calibers: Steel shells, all fuses; incendiary shells.

118. *Casemates, protected magazines, concrete work, bombproof shelters, etc.*

According to the protection: **120** *millimeters*, **155** *millimeters*, and *above*. (The use of caliber 155 millimeters is generally sufficient for shelters having only covered ways.)

Shell (preferably of steel).
- 20 per cent delayed action or 0 delay (angle of incidence $< 30°$), to excavate.
- 80 per cent long delay (angle of incidence $> 30°$), or with delay 0.05 second (angle of incidence $> 30°$, to break up the protection.

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From several suitable charges it is preferable to select the one which gives the largest margin of adjustment on both sides of the assumed range. Then make certain that the charge selected *arms the fuse* employed for the given matériels.

If no attention need be paid to the angle of fall, select the charge which allows the target to be reached with a sufficient margin of adjustment. To reduce the wear on the matériel, use the heaviest charges only in the following cases:[1]

(1) When the range does not permit the use of another charge.

(2) In very exceptional cases, when it is possible to obtain greater precision in this manner and when a very high degree of precision is needed for the fire.

Avoid ricochets, which render the adjustment difficult and are useful only against unsheltered personnel. They occur when the angle of incidence is less than 15°, and may even occur frequently between 15° and 25°.

124. Read in the practical tables (Table VI), the *elevation*, the fourchette, and the drift corresponding for the projectile and charge used, to the given range.

Then send to the guns the correction for deflection. Add to or subtract from the elevation found the angle of site, and the complementary correction (Tables III and III bis) depending on whether the target is higher or lower than the battery.

For guns having a site apparatus, the site is given directly by the command: "*Angle of site, plus or minus so much.*"

125. Correct the deflection and the quadrant elevation in accordance with the data at hand by the drift due to the wind, the variation in initial velocity due to the powder lot and its temperature, and the variation in range due to the wind, temperature, and pressure. If the data necessary to make these corrections is not at hand, give the quadrant elevation by multiples of five minutes. Send the deflection data to the guns. *The quadrant elevation is not sent until the last, as a command of execution.*

126. Enter all these figures in the firing-data book (see chapter on firing-data book). Verify all operations and calculations while the battery is executing fire.

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[1] Note, moreover, that the alternation of charges BC and BG_8 seems to wear out the copper sheathing.

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This method assumes—

(*a*) That the atmospheric corrections are well known.

(*b*) That the second fire is executed under the same ballistic conditions (same lot of projectiles, same lot of powder at the same temperature), or that the corresponding corrections have been made.

The corrected range may be different from the topographic range. If a second adjustment gives different results, compare the conditions under which they have been obtained. If one was made under less favorable conditions (utilization of the results of a former sounding, unsettled weather, unknown lot of powder) retain the results of the other. If the conditions are similar, strike an average of the results. If the position of the target is absolutely known, there may still be doubt as to the position of the battery. If the position of the target is known only approximately, it is best to rectify it temporarily, on condition of knowing the exact angle of site, and to send immediately the new coordinates of the target to the aritllery commander. Under these conditions, the gun becomes a veritable range finder.

In mountainous country, we adopt as the value of the coefficient of reduction of the range the ratio $\frac{A-R}{A}$.

II. UTILIZATION OF THE RESULTS OF A PREVIOUS FIRE ON ANOTHER TARGET.

130. The process employed is called *transfer of fire.* The first target is called the auxiliary target. We may even utilize the results of previous fires of a neighboring battery, but on condition that—

(1) The determinations of the positions of the two batteries are equally accurate.

(2) The caliber, the projectiles, and the lot of powder are the same.

TRANSFER OF FIRE.

131. *Definitions.*

The correction for the adjustment in angle is the difference between the quadrant elevation obtained by adjustment and the quadrant elevation calculated for the range and sites of the target.

The angle of transfer is the angle between the auxiliary target and the real target, modified by the difference in drift.

PRINCIPLES.

132. The auxiliary target should fulfill the following conditions:

(1) Have a position that is accurately known.

(2) Lend itself to a continuous and easy sensing of the rounds in range and in direction.

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(3) Be near enough to the real target so that the ratio of the ranges from the battery to the auxiliary target and to the real target will lie between 4/3 and 3/4, and so that the angle of transfer will not exceed 200 decigrades.

We choose, if possible, hostile work (an observation station, for example), or any other point upon which adjustment may produce a useful effect. One fire should follow the other immediately in order to have the atmospheric conditions alike.

REGULAR METHOD.

133. *Range.*—Calculate the coefficient of adjustment in range on the auxiliary target and multiply the topographic range of the real target by this coefficient. Find the corresponding elevation and correct it for site if necessary.

The order of operations is as follows:

Adjustment quadrant elevation..... =
Total correction for site, with reverse sign..... =
Adjustment elevation..... =
Adjustment range (R)..... =
Range read on the plotting board (A)..... =
Coefficient of adjustment $\frac{R}{A}$..... =

The importance of a site apparatus which separates the angle of site from the elevation is self-evident.

Deflection.—Shift the deflection by the angle of transfer. This method, although called regular, is not absolutely exact, for we have arbitrarily assumed that the corrections in range were proportional to the ranges.

SIMPLIFIED METHOD.

134. When the two targets are very close together their adjustment ranges are approximately the same. When the coefficient of adjustment in range is in the neighborhood of 1, the corrections are very slight. In either case we simplify the method as follows: The elevation calculated for the real target is simply modified by the correction for the adjustment elevation corresponding to the auxiliary target. If this first elevation has not yet been calculated, add to the adjustment range of the auxiliary target the difference in range between the two targets. Adopt the quadrant elevation corresponding to the range thus found and the angle of site of the real target.

The method is the same when the gun has a quadrant graduated in ranges.

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Remarks.—When neither of these methods is applicable, we must—

(*a*) Execute fire for effect on a zone whose dimensions are those of the target increased by 5 decigrades to the left and to the right and a half fourchette both short and long.

(*b*) Control the fire, if possible, and at the same time, or soon afterwards, verify the adjustment quadrant elevation on an auxiliary target with one gun while the others continue the fire for effect.

(*c*) If, in the course of fire, there is reason to fear that the adjustment has been thrown out (for example, if the atmospheric conditions vary, or if it becomes necessary to change the powder lot), the adjustment quadrant elevation must in like manner be verified on the auxiliary target, and the corrections found for range and direction must be made integrally.

VERTICAL FIRE.

135. *The same method.*—The correction for site is made on the range.

SYSTEM OF THE PIECES.

136. If we consider the points of fall resulting from the fire of each of the pieces of the battery, under the same conditions of fire, each of them will have a special center of impact and area of dispersion. By the system of one gun with respect to another taken as a standard of comparison, we mean the difference between the positions of the centers of impact and the extent of the areas of dispersion. In practice, we take as a standard of comparison an ideal piece whose center of impact and area of dispersion are those given by the tables. It will frequently be found that the system of a piece, compared to the typical piece as given in the tables, is measured at all ranges by the same number of fourchettes. In this case it should be expressed in fourchettes. In the same manner, when the system of a gun has been determined for only one range, we add the same number of fourchettes for the other ranges for the first approximate value.

In a well-maintained battery, and with pieces that have been fired but little, the system of all the pieces is approximately the same, and the points of fall of the projectiles fired by the different pieces may be considered as those of a single piece. But when a battery includes pieces which have fired a great deal, the systems of these pieces must be taken into account. The battery commander takes advantage of all opportunities to become familiar with the different systems corresponding to the different conditions of fire (charge, range, etc). He also tries to have each piece fire the same number of rounds with the same charges.

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VERIFICATION OF THE AIMING CIRCLE IN DIRECTION.

142. Place the quadrant's range scale and the site graduation at zero. If the piece has no sighting line, use a bore sight and muzzle cross hairs, or breach and muzzle cross hairs. Place the air bubbles of the two levels between their graduations, and lay the piece on a distinct point at sufficient distance. (If a distant point is not available, construct an adjustment target.) Adjust in direction on this point, turning the azimuth micrometer only in the direction of increase. Repeat this adjustment in the direction of diminution. Repeat these operations with the rear sight extension leaf. Measure the errors, and note them. If the error is too large, report it to the mobile repair shop.

FIRING-DATA BOOK.

143. Distinguish between the data book containing the data and the results, in which the fire corporal writes the commands given by the battery commander and the results of observation, and the *firing notebook*, which contains the topographic data of the position notebook and in which are recorded the results of the adjustment of fire, the data for prepared fire, and the system of the pieces.

Models of these notebooks are distributed to the armies. When these notebooks are not at hand an ordinary notebook may be substituted in the following manner:

On one page is recorded all data about the target—nature, coordinates, altitude, range, photographs and sketches, history of the periods of occupation or activity, dates and results of fire on it, new coordinates, and the new range resulting from the adjustment made. On the opposite page is recorded the preparation and the result of adjustment, the elements calculated from the most recent sounding, if necessary to be ready to open fire again at any moment.

An index enables us to find immediately the page of the target which we desire.

There is also a page of tables of comparison of the aiming instruments at different directions and at different angles, and another page of tables of comparison of the pieces at different ranges.

Example:

Fire of: Hour.

Target { Designation
Coordinates: $x=$ $y=$ altitude:

Ammunition { Charge Powder lot
Projectile (weight) Fuse

Barometric pressure Temperature: Wind { Direction.
Velocity.

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PART III.

CHAPTER VII.

Terrestrial Observation.

GENERAL REMARKS ON OBSERVATION.

145. The zone of observation is the area included between the straight lines from the observer to the right and left extremities of the target.

The firing of each salvo or round is announced to the observer so as to prevent unnecessary fatigue and to permit him, by knowing the time of flight, to distinguish the rounds fired from the neighboring bursts.

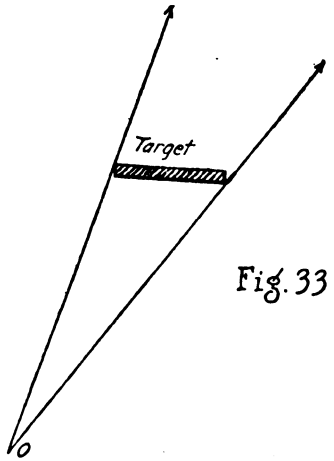

Fig. 33

In fire by salvos, the rounds are fired in the order of the pieces, at intervals convenient for the observer, beginning with the leeward piece, so that the smoke from one round does not hinder the observation of the following ones.

The results of observation are transmitted in the following order: *Range, height of burst, deflection.*

OBSERVATION IN DEFLECTION.

146. First of all, the observer chooses on the target itself the points at which he desires the rounds to fall. If the target is slightly visible, he chooses the most distinct point as the *adjustment point.*

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AXIAL OBSERVATION.

148. The observation station is approximately on the line battery —target; that is, the angle between the line of observation and the line of fire is less than 100 mils.

If the observation station is near the battery, the observed errors in deflection are sent to the pieces without correction.

Ratio of deduction.—When the ratio between the distance observer —target and the range battery—target is greater than 2/3, the amount of the observed error in deflection must be multiplied by this ratio.

Demonstration.—Let d and D represent the distance from the observer O to the target B and the range from the piece P to the target B, respectively.

Then—

$$\beta = \frac{\alpha d}{D}.$$

on condition that A is at almost the same distance from O and P as B is from these points; that is, that there is only a slight error in range in the burst. Otherwise B must be replaced by a, the point at which the perpendicular from A intersects OB.

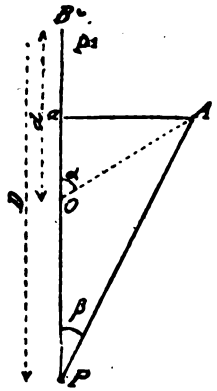

Fig. 34

The observations on the heights of bursts are reduced by the same ratio.

Remarks.—

I. A balloon observer, since he is able to locate the line joining battery and target on the terrain, effects axial observation.

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II. The ratio $\frac{d}{D}$ will usually be given by very accurate maps. When it is not known, it must be assigned a simple value serving to correct the deflection after the first round. When two rounds have been observed, a more exact ratio can be obtained. In fact, if the range of these two rounds is practically the same, the exact ratio is:

$$\frac{\text{correction ordered}}{\text{error between the two rounds.}}$$

LATERAL OBSERVATION.

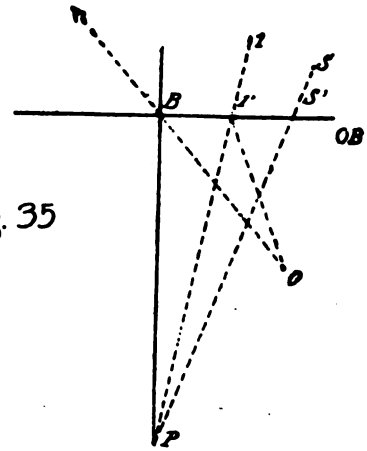

Fig. 35

When the angle between the line of observation and the line of fire exceeds 100 mils, the observation is called "lateral."

THE ANGLE OBP IS EQUAL TO OR LESS THAN 45°.

149. It becomes a question of placing and maintaining the rounds on OB, or at least in the zone of observation.

(1) *To place the rounds on OB.*—Let the first round be at 1. If, thanks to a knowledge of the terrain, the point 1′, on the plane of fire, at the same range as B, can be located, the correction in deflection 1′ OB instead of 1 OB is made with the desired reduction and a correction in range is made to bring the next round on B.

In like manner, when no battle map is available and it is impossible to measure the angle BPS (PS being the axial line of observation), an attempt is made to locate the point S′.

If 2 and 3 have been fired at the same range, 2 P 3 is the correction given to the piece which has produced the observed error 2 O 3, and we deduce the correction to bring the burst 4 on OB.

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But, as a result of the large dispersion in range (which is between 4 and 25 times greater than the dispersion in direction), the result will be obtained only after a certain number of rounds have been fired.

As in all phenomena of dispersion, it will be necessary to consider all the rounds observed at the same quadrant elevation, taking an average of the ratios of reduction found. After a round has been placed on OB and has been observed in range, make a jump in range to find the bracket.

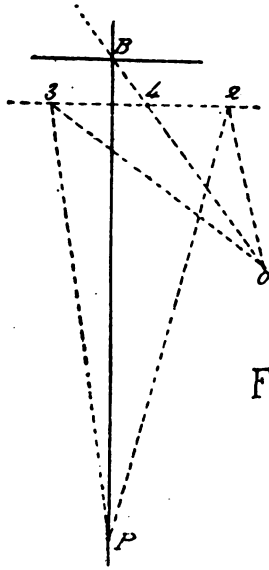

Fig. 36

(2) *To maintain the rounds upon OB.*—Lay off on the plotting board the length BF=n fourchettes in range. Draw FD perpendicular to PB. The angle FPD is said to be n fourchettes in direction.

To each modification of the quadrant elevation of p fourchettes in range, there should be a corresponding modification of p fourchettes in direction in the sense desired, and, to avoid later delay, we should note this sense.

If a plotting board is not available, this fourchette must be determined by observation in the following manner: After the jump in range necessitated by the round 4, place the next round on OB by a

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series of corrections in deflection which give the rounds 5, 6, 7, and finally 8 on OB.

The difference between the new deflection obtained, P 8, and the preceding deflection, P 4, gives a first value of the fourchette in deflection.

Here again, the dispersion in range intervening, it is well to take account of all the rounds observed, 5, 6, 7, 8, and the fourchette thus varies by successive approximations.

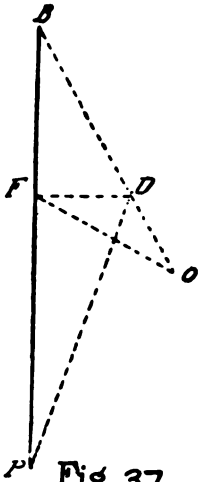

Fig. 37

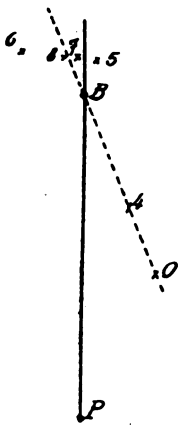

Fig. 38

Moreover, we must take into consideration the variations in the ratio of reduction when passing from the range of 4 to that of 5, 6, 7, 8. We continue the fire until the desired bracket is obtained.

150. *Special cases.*—

I. If, at the beginning, the rounds are evidently too far from the target, there need be no hesitancy in changing the quadrant range immediately, in order to avoid extensive changes in direction, which are always difficult to make with heavy guns.

But if the quadrant range is thus changed when opening fire, we must not vary the deflection at the same time; for if we do, we risk losing the chance of reaching a conclusion from the round.

II. If, in course of fire, a round strikes the target, the deflection is evidently adjusted. It should therefore be left alone, and we con-

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tinue the fire, considering (for an observer on the right of the line of fire, for example) as over the rounds falling to the right, and as shorts those falling to the left of the line of observation.

III. It has been seen that, as a result of the dispersion in range, the placing of a round on OB may become a long operation. Consequently adjustment by lateral observation on a target which appears as a point from the observation station may likewise be a long process, unless the range can be estimated approximately, thanks either to the observation station being near the target (advanced observation), or to the fact that it completely commands the target (the case of the airplane).

On the other hand, adjustment is rapid if the target is of a certain width (a trench, for example). But even in this case we must choose a point B on the target to give us our line OB, and this point B must be chosen so as to coincide as nearly as possible with the center of the target, in order to have the maximum number of rounds observable in range. (If the target is wide, ammunition may be economized by not insisting on placing a round exactly on OB; but the corresponding correction is nevertheless made to obtain as accurate values as possible for the ratio of reduction and the fourchette in direction.)

IV. When the target does not lend itself to estimating the sense of the errors in range by being obscured by the smoke ball or being silhouetted against it, either on account of its small width, or for any other reason, the sensing in range may nevertheless be made *if the deflection is already adjusted*, since every round observed to the left is short and every round observed to the right is over when the observer is on the right of the line of fire. But the precision of adjustment in range then depends on the precision of the observation in deflection and the inclination of the line of observation to the line of fire.

We have seen that a good observer, provided with well-adjusted instruments, can observe for deflection to within 1 mil or one-half a decigrade. Let ϵ be this angle. The observer then announces as "deflection correct" every round that falls at less than ϵ from the target. Let BF be the fourchette. If FOB is greater than 2 ϵ (1 decigrade or 2 mils), the adjustment can be continued until the bracket is obtained. If FOB is small (about the value of a decigrade), its graphic determination has no value. The minimum bracket 2 BQ is then calculated in the following manner:

The angle BOM=ϵ.

BO and OK are measured on the plotting board.

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First of all, BM must be calculated (either by the aid of Table II of the tables, or by the formula for parallax, $f=md$).

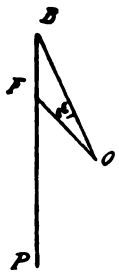

Fig. 39

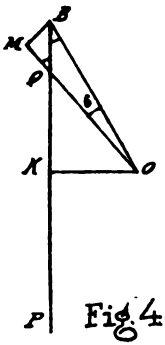

Fig. 40

Now, the angles MOB and QBO are practically equal. We therefore have the relation given by assuming as similar the triangles MBQ and KBO:

$$\frac{BQ}{MB}=\frac{BO}{OK},\ \therefore BQ=MB\times\frac{BO}{OK}.$$

BQ is half the length of the limiting bracket. Express it in fourchettes (brackets of four probable errors).

Example: If BQ=1¼ fourchettes, the minimum bracket is 3½; therefore limit the bracket to 4 fourchettes, and execute fire for effect on this zone of 4 fourchettes.

I. We therefore see that it is well to increase the angle FOB; to do so, we must find an observation station near the target and near the perpendicular to the plane of fire at B.

II. To adjust the deflection, we should have a second observation station. If it is axial, the observation is called "*combined*"; if lateral, the observation is termed "*bilateral.*"

THE ANGLE OBP IS GREATER THAN 45°.

151. The dispersion in range is so great that the preceding method becomes practically impossible. In such a case the inverse method must be employed.

(1) Bring the rounds on OB by variations of the quadrant elevation only, and draw conclusions as to the corrections in deflection.

(2) Maintain the rounds on OB by modifying the range at the same time as the deflection.

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An observation station so far off the axial line is practically useful only when it is near the target (advanced observation), or else when it is associated with a second observation station, axial (combined observation) or lateral (bilateral observation).

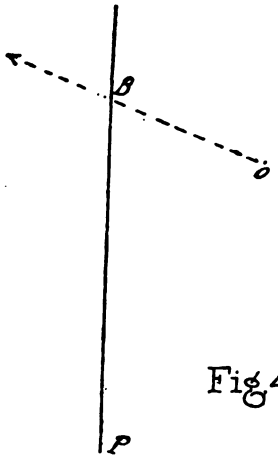

Fig 41

ADVANCED OBSERVATION.

152. This is observation near the target. If the target is near our lines, this method of observation should be employed, primarily because it enables us to estimate, often perfectly, the sense of the rounds, thereby assuring the safety of our first-line troops. Occasionally it may be possible to have an O. S. on the axial line. Ordinarily, however, it is placed laterally. Therefore the deflection can be adjusted only after the range.

Nevertheless, from the opening of fire an idea of the deflection of a round may be obtained by imagining the intersection of the plane of fire with the ground and finding its intersection with the target, provided the latter is wide enough (for example, enemy trenches on line with the obstacle to be demolished).

COMBINED OBSERVATION.

153. Combination observation is the association of an axial O. S. with a lateral O. S., which gives the range by simple observation for deflection.

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is "short." If the index is zero, the round is near the target. Every round with an index less than 1 decigrade or two mils is announced as "doubtful," since the error of the index may be equal to the sum of the errors of each observation station—that is, two half decigrades or 1 mil.

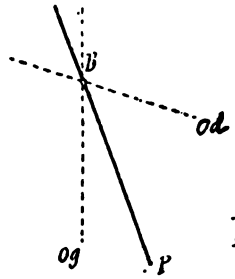

Fig. 43

The fire is executed round by round.

Adjustment in deflection.—The correction is equal to half the algebraic difference in errors.[1] Perform this operation in such a way that the correction to be ordered will have the sign found.

Adjustment in range.—Value of the bracket limit.—Find, as in the preceding case, the bracket limit from each of the observation stations. As a measure of safety, take the largest.

Continue adjustment fire until the bracket limit has been obtained and execute fire for effect on the zone of this bracket. To make the operations easy and certain, establish the following table in advance:

Number of rounds.	Right-hand observer.		Left-hand observer.		Index of the round.	Sense in range.	Algebraic difference.	One-half algebraic difference.	Mean ratio of reduction.	Commands—	
	Observation announced.	Algebraic equivalent.	Observation announced.	Algebraic equivalent.						In deflection.	In range.

[1] This rule assumes that the two observation stations are placed symmetrically with respect to the plane of fire. In practice, however, the approximation is sufficiently accurate.

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(1) We therefore see that it is advantageous to install the two observation stations on either side of the line of fire, and mark them symmetrical, as far as possible, with respect to the plane of fire and as near to the target as transmission conditions permit.

(2) Nevertheless, we must not hesitate to associate a very advanced observation station on the flank with one near the plane of fire, for, as soon as the deflection is adjusted, the advanced observation station will give the range with great precision, and enable us to execute a verifying fire, the other station serving only to watch the deflection.

155. *Graphic method.*—For an important fire of large caliber, a plotting board may be established, drawn to a large scale (for example 1/2000).

As soon as possible, establish a third observation station. The three directions plotted on the plotting board will give a triangle which will enable us to determine the coordinates of the point of impact.

To facilitate rapid operation, the plotting board should have diverging straight lines, spaced in decigrades or mils, and numbered on either side of the lines of observation.

The adjustment then consists in correcting, after each round, the deflection and range by the size of the observed error, divided by the number of the round.

This method of intersection demands:

(1) That the observation stations be spaced far enough apart for the extreme lines to intersect at angles of at least 30°.

(2) That in each of the observation stations the angular errors be measured from distant points that are well known.

It is to be noted that when the observation station is thus organized, any point whatever can be chosen as an auxiliary target, especially one of the points of impact.

MEANS OF OBSERVATION.

156. *Instruments.*—The instruments for observation which the observers may have at their disposal are the B. C. ruler, the sighting triangle, prismatic field glasses, glasses and telescopes of various models.

I. *B. C. ruler.*—A simple scale graduated in mils and provided with a fixed cord of such length as to allow the reading of the graduation in decigrades (or in mils of 6,400 or 6,000). Each observer constructs his own graduated scale.

II. *Sighting triangle.*—See Regulations on the Observation Service.

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III. *Prismatic field glasses.*—The field glasses in use are of different models. They have a micrometer graduated in decigrades or mils. Always rest them against a solid support. A support, made as follows, renders the best service: Two clips clamp the central column and are mounted on a transverse axis allowing the necessary inclination; the whole instrument turns around the center of a protractor, equipped with a vernier.

IV. *Glasses.*—The glasses used in observation are: The battery telescope, the siege telescope of varying magnifying power, the telescope for night observation, the monocular, and glasses and telescopes or binoculars of different models.

PANORAMA SKETCHES.

(Paragraphs 157 to 160 omitted. Published in "Manual for the Artillery Orientation Officer.")

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PART IV.

EXECUTION OF FIRE.

CHAPTER VIII.

Rôle of the Battery Officers.

161. The battery commander must be familiar with the ability of his inferiors and able to use them in the best interests of fire.

As a rule, he takes a position from which he can see and command his battery and at the same time observe its fire. If there is no post fulfilling these conditions, he remains during fire at either the observation station or the battery. He considers the condition of his personnel and the difficulties of fire in deciding at which post his presence is more imperative. When he deems it necessary to be at the observation station, he entrusts the command to his senior subaltern, giving him orders on the conduct of fire and the method of liaison. When, on the other hand, he judges his presence necessary at the battery he indicates the target to the observer (whenever possible from the observation station itself), informing him precisely as to the conditions of observation and giving him orders for the transmission of results.

Fire corporal.—The fire corporal is the battery commander's fire secretary. He records the commands as announced, as well as the results of observation, in the firing-data book.

CHAPTER IX.

Adjustment of Fire.

162. *General remarks.*—The degree of precision desirable in adjustment depends on the fire to be executed as a result of this adjustment; consequently, it varies with the nature of the target and the tactical situation.

If it is a question of quick action against an enemy sheltered either slightly or not at all, we execute a trial fire, even if immediately afterward it becomes necessary to fire systematically on the

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bracket obtained. If, on the other hand, it is necessary to disorganize a very solid position, the adjustment must be continued to include the verifying fire.

Adjustment is therefore a function of fire for effect; hence, the battery commander must know definitely his course of action and the results he hopes to obtain therefrom. (See par. 120.)

ADJUSTMENT IN DEFLECTION.

163. (1) Before opening fire, the battery commander determines one or more points (adjustment points) upon which he wishes to see the rounds fall. Against narrow targets, or wide ones presenting only a narrow surface that is clearly defined, all pieces are adjusted with respect to the same point. Against wide and moving targets, fire is immediately adjusted in deflection so as to cover the entire target.

The battery commander chooses a *reference base* for deflection close to the target (if not on the target itself), and a *reference base for height* of burst or for site.

(2) Adjustment in deflection is executed by piece. It is assured by the chief of section responsible for the execution of all corrections sent.

(3) The observer announces the sense and size of the errors. These are corrected as a whole. The direction of the graduations of the aiming circles (except in the jacket goniometer) is such that an increase carries the fire to the left and a diminution to the right.

Avoid the command "As you were," which confuses the personnel. If the battery commander has been mistaken and has given the command "Add 10," to carry the fire to the right, he must let it stand and order twice the correction in the opposite direction; that is, "Subtract 20."

(4) When the error does not exceed 2 decigrades, the deflection is corrected only if several successive errors in the same direction render it advisable. However, in fire demanding very great precision, it may be corrected if the error exceeds 1 decigrade.

(5) The battery commander tries, at the opening of fire, to bring the bursts in the direction of the target (or that part of the target chosen for adjustment) so as to be able to observe the rounds for range as soon as possible. As the fire continues, he finally adjusts the deflection of each piece. Moreover, the deflection is constantly observed and corrected, if necessary, in the course of verifying fire and fire for effect.

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If the sensing of the rounds thus fired is still contradictory, the quadrant elevation (or range) is provisionally adopted as that of the range to the target (provisional quadrant elevation or range).

If the two rounds fired have the same sensing, this sensing is adopted for the quadrant elevation (or range).

If in one of the salvos a round falls on the target, this round is considered as in the sense contrary to that of the other round of the salvo, and the above rules are applied.

There is thus a contradiction if there is a short (or over) and a round on the target. If, after a contradiction, a second salvo gives a round on the target, the quadrant elevation (or range) is adopted as the provisional one.

166. *Verification of a quadrant elevation.*—To verify a quadrant elevation we proceed in the following manner:

Fire two rounds with the quadrant elevation to be verified. If the two rounds have contrary sensings, we adopt the quadrant elevation as provisional.

If the two rounds have the same sensing, we continue the trial fire, proceeding by jumps of half a fourchette.

CONDUCT OF FIRE.

167. Fire for adjustment includes two phases:

(*a*) Trial fire, consisting of bracketing the target in a zone whose two limits correspond to *verified* quadrant elevations differing by one fourchette. In the course of this fire, we adjust the deflection.

(*b*) *Verifying fire.*—When a certain number of rounds have been fired and observed (generally six, but the more there are the more certain is the result obtained), we locate the position of the center of impact with respect to the target, deduce the correction to be made in the quadrant elevation to bring this center of impact on the target, and thus obtain the adjustment quadrant elevation.

Trial fire is opened with the quadrant elevation furnished by the preparation for fire, i. e., the *initial elevation*.

Verifying fire is opened with the mean of the two verified bracketing quadrant elevations obtained from one trial fire, or with the quadrant elevations which have given an equal number of shorts and overs in the verification of the quadrant elevations. It is called the provisional quadrant elevation.

TRIAL FIRE.

168. We fire round by round with the large calibers. With the medium calibers we generally fire by platoon salvos (if the system of the pieces is well known), or by two rounds from the same piece.

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A round on the target is considered to have a sensing contrary to that of the majority of the rounds.

Remarks.—

I. This method of bracketing takes no account of the size of the errors. There should, therefore, be energetic opposition to the tendency displayed by beginners in assuming that a round is only slightly short or over and failing to verify the long and short limit, or in considering themselves justified in not firing the second verifying round. This always delays adjustment, and often renders it inaccurate by reason of the errors of observation arising from a preconceived idea.

II. In adjustment, never try to gain time by deviating from the precise rules given by the Regulations. These rules are the fruit of many years' experience of certain results, and a misinterpretation of them always leads to a waste of ammunition.

SPECIAL CASES.

170. (*a*) *Changes in the conditions of fire.*—When we reopen a fire previously adjusted under certain atmospheric conditions, and every time the powder lot is changed in course of fire, the quadrant elevation is verified.

When, in the course of fire, the type of projectile is changed, the corrections to be made to the quadrant elevation and the deflection are determined in accordance with the range tables, and the quadrant elevation is verified.

(*b*) *Commands in range.*—For certain matériels, the commands are given in ranges. The fourchette is given in meters by the tables. The quadrant range given by the whole fire is expressed in round numbers in multiples of 25 meters.

With these exceptions, the rules for fire are applicable as a whole.

PLUNGING FIRE.

171. Same general method.

Remark.—After the trial fire see that the angle of fall corresponding to the provisional quadrant elevation is still greater than the minimum angle indicated. For this purpose, find in Table VI the range corresponding to the provisional quadrant elevation and read in Table IV the angle of fall corresponding to this range. If this angle of fall is less than the minimum angle, adopt the smaller charge, and find, in Table VI, relative to this new charge, the quadrant elevation corresponding to the range found by adjustment. Adopt this quadrant elevation as the provisional one. Modify the deflection according to the changes in charge and quadrant elevation.

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VERTICAL FIRE.

172. Same general method.

Remarks—

I. In vertical fire, a diminution in range and in increase in deflection corresponds to an increase in the quadrant elevation. To see this, we plot on a plotting board, drawn to a scale of 1/20,000, the points of fall obtained with the same charge but with different quadrant elevations. By joining these points a curve of the form given in the figure is obtained.

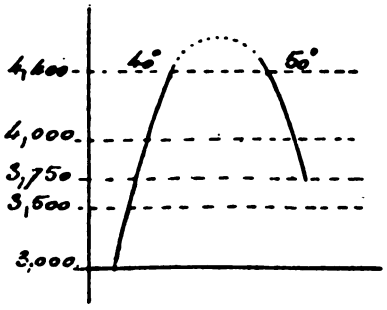

Fig. 44

II. When variations in deflection are very large, it becomes necessary to make modifications in direction corresponding to every change of quadrant elevation in the course of fire and to every change of charge.

III. If the fire gives a short with a quadrant elevation of 50°, or an over with the maximum quadrant elevation permissible with that carriage, the charge must be changed. For this purpose, take from Table VI the range corresponding to the limiting quadrant elevation with the charge tried. For the new charge, take as the quadrant elevation the one corresponding to the range just found.

IV. The first round fired by each piece is used only for adjustment in deflection. (For obscure reasons, the first round fired from a gun often varies largely from those following. The error assumes a certain importance in vertical fire.)

ADJUSTMENT ON A TARGET IN THE NEIGHBORHOOD OF FRIENDLY TROOPS.

173. Note the following:

(1) The fragments of a heavy artillery shell may be projected several hundred meters (600 meters for the 155-mm. elongated shell). Therefore we must warn the occupants of the trenches to seek cover.

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(2) The phenomenon of dispersion may place a round on our lines with fatal results when the distance from the target to our lines is less than one-half the zone of dispersion. Therefore:

(*a*) We request the evacuation of our trenches which are within six probable theoretical errors (according to the tables) of the target; that is, within a fourchette.

(*b*) We take all precautions to prevent an increase of dispersion in course of fire. We apportion projectiles and charges with the greatest care. We verify the charges. We take atmospheric variations into consideration.

Conduct of fire.—Adjust by pieces. Always see to it that the first round is at a safe distance from our trenches. Approach the target carefully, by small jumps.

DATA BOOK.

174. The data book contains: (1) The calculations of the initial data by the battery commander; (2) the battery commander's commands and the results of observation recorded by the fire corporal. This data, when consolidated, therefore forms a record of the adjustments effected.

CHAPTER X.

Fire for effect.

175. Before opening fire for effect the battery commander warns the observer.

In order to be certain in the use of the results of adjustment, fire for effect should immediately follow fire for adjustment.

The sheaf is opened or closed by the proper amount, if this has not already been done.

No matter what method of observation is employed, fire for effect is of two types:

(1) Accurate fire for demolition, when observation is continuous.

(2) Zone fire, when observation is not continuous.

ACCURATE FIRE.

176. Each piece is adjusted individually, and a series of 12 rounds is fired with the adjustment quadrant elevation and with projectiles of the same weight and with the same powder lot.

The corresponding command is, for one piece: "Deflection so much; quadrant elevation, so much; so many rounds per minute."

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The quadrant elevation is modified by as many times one-twelfth the fourchette as there are rounds to be changed from one sensing to the other.

When several pieces are employed against the same target, we suspend their fire periodically, and have each fire a new series of 12 rounds, correcting, if necessary, the quadrant elevation This suspension enables the other pieces to rest and cool for a time; they should remain unloaded, with breech open. Overheating the pieces generally changes their range.

Fire is continued until the result sought is manifestly obtained or until the ammunition allotted for this fire has been exhausted.

After demolition fire, it is usually well to prevent the repair of the enemy's works by intermittent fire with instantaneous fuses. This fire will have its maximum effect of surprise if it is executed by battery volleys of one round.

ZONE FIRE.

177. When observation is impossible or when it ceases, or when it does not enable us to reduce the bracket, fire is distributed over a zone of variable dimensions.

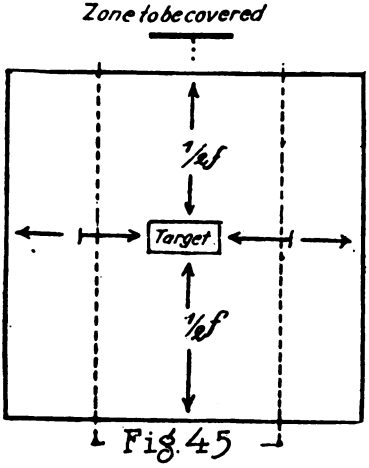

Fig. 45

Dimensions of the zone.—After a transfer of fire, the zone is taken as the surface of the target, increased by 5 decigrades to the right and to the left and by ½ a fourchette over and short. This also applies when observation is suddenly interrupted, and the fire is continued,

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with periodic verification on the reference target. It also applies when a fire, which has already been adjusted, is resumed with data corrected by a recent sounding.

When the bracket can not be reduced, the zone is that of the limits of the bracket.

In the exceptional cases when no adjustment can be made, the zone will be extended to 2 fourchettes on either side. Finally, if the corrections can be determined only approximately, or if the position of the target is not accurately known, the zone is doubled.

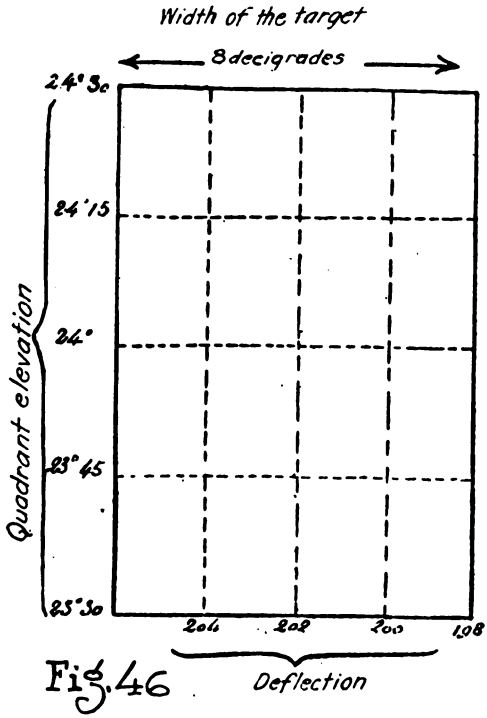

Fig. 46

Distribution of fire in the zone.—

In range:

One-half fourchette for ranges less than 4,000.

One-quarter fourchette for ranges greater than 4,000.

In deflection:

Two decigrades.

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The discharge of each salvo (round) gives rise to the following exchange of communications between the battery and the observer. "*Ready to fire;*" "*Ready to observe;*" "*Salvo (round) fired.*"

"*Salvo (round) fired*" must be announced immediately after the salvo (round) has been fired, so as to limit the time during which the observer observes the target, and to enable him, when circumstances require it, to distinguish the rounds fired by the battery from other bursts near at hand.

A. MEAN CALIBERS (LESS THAN 200 MILLIMETERS).

180. *Fire for adjustment.*—When the airplane signals "Fire," the battery fires by salvos, in the order of pieces, beginning with the leeward piece, at prearranged intervals known to the observer (from 1 to 10 seconds), parallel fire, with the same quadrant range taking account of the special system of each piece, if necessary.

It is indispensable to have the first salvo fall in the region where it is expected by the observer; for this purpose, the position of the battery must be definitely determined and the initial data carefully corrected in accordance with a recent sounding.

So far as possible, the sheaf should be verified previous to adjustment, to avoid individual corrections in deflection which take considerable time and may result in confusion.

If the battery is unable to fire during the 20 or 30 seconds following the order "Fire," it waits until a second order is given.

If it can not immediately continue fire (due to an accident, to a hostile airplane flying over our lines, to persistent wireless interruption, etc.), it warns the antennæ officer. (The conduct to be maintained in the presence of a hostile airplane is determined by the staff. In case of attack fire should be continued. In a period of calm it is usually best to suspend fire until the hostile airplane can no longer observe).

As soon as the battery is again ready to fire it announces "*Battery ready.*"

After the first salvo, the corrections in deflection and range announced are laid off as they are received. After the following salvos, the battery notes only the sensing of the salvos, and strives to obtain the bracket.

A salvo signaled "*Not observed*" should not be fired again with the same data. The following salvo is fired with data intermediate between that of the last observed salvo and that of the unobserved salvo.

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(*b*) *Systematic fire.*—This is a fire for effect opened with unverified data—the data of a previous adjustment on that target, for example.

This fire should be executed on a deep zone, on account of the uncertainty of the initial data; but to facilitate aerial observation the depth of the zone fired on is reduced to one fourchette.

B. LARGE CALIBERS (EQUAL TO OR GREATER THAN 200 MILLIMETERS).

183. I. *General method.*—Fire is always executed round by round. The preceding method is applicable in verifying the limits of a bracket of one fourchette.

184. II. *Method of the amount of the errors.*—When the observer can give, *with absolute certainty*, the amount of the errors, the battery commander may employ the following method:

After each round we correct the deflection and the range by the amount of the error divided by the number of the round up to the time when, on two different occasions, the correction becomes less than one-sixth of a fourchette and one-half a decigrade. From this time on we conduct fire as though a first verifying fire of six rounds had been executed. The observer continues to observe the fire.

No notice is taken of rounds not observed.

Remarks.—

I. This method can evidently be used only when the amount of the errors is accurately known. Ordinarily it is applicable only when we have the cooperation of an aerial observer able to estimate *with absolute certainty* the amount of the errors. For this reason it is described at this point only.

It may be employed in exceptional cases when two observation stations whose positions are well known are able to give accurately, by the method of intersection, the respective positions of the target and each of the rounds. If a third observation station is available, we must not fail to use it, for it affords a means of verification.

II. This method is adaptable only to large calibers.

(1) It demands fire round by round.

(2) It assumes slight dispersion, for it gives as a result an adjustment quadrant elevation determined with a smaller number of rounds than in the method of bracketing followed by verifying fire.

FIRE ON A REFERENCE TARGET.

185. When a satisfactory adjustment has been obtained by airplane or balloon on a target invisible from the terrestrial observation stations, it is advantageous to resume fire without again resorting to aerial observation.

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With this in view, immediately after adjustment by airplane, we proceed to a special adjustment on a reference target[1] easily visible from the terrestrial observation stations.

In this way there are obtained two simultaneous adjustment quadrant ranges, corresponding, respectively, to the real target and the reference target. We must note the relation between these two quadrant ranges, for this relation remains constant at all times.

If later it is desirable to resume fire on the real target, we adjust first on the reference target. Thus a new adjustment quadrant range is obtained.

The quadrant range of the real target corresponding to this latter represents exactly the quadrant range of the real target at the moment under consideration, and fire on the real target may be resumed.

Remarks.—This adjustment on the reference target may be accomplished with a single piece while the others continue fire on the target. The same thing is true of the periodical verifications during the course of fire for effect.

In the course of fire for effect (systematic or controlled), when observation is no longer possible, we must verify periodically to see that the fire is kept in adjustment.

Chapter XII.

Time-Fuse Fire.

186. *General remarks.*—Only the average calibers have shrapnel or case-bursting shrapnel, and they are generally the only ones to use time-fuse fire. They should be employed not for instantaneous attacks on movable targets or for their pursuit, but to fire at certain hours on points of assembly and of passage a great distance away, and, in exceptional cases, to attack special targets, such as balloons.

A few time-fuse projectiles bursting high may be very useful to adjust quickly the deflection of a piece or to verify a sheaf.

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[1] The reference target should accordingly have the qualities of an auxiliary target; that is, it should be readily visible from a terrestrial observation station and as near as possible to the invisible target. It is distinguished from the auxiliary target in that adjustment is made on it during or after fire with airplane observation, while adjustment is made on the auxiliary target before this fire. Moreover, for lack of better, it may be chosen beyond the limits fixed for the auxiliary target, and even a point whose topographical position is not well determined may be chosen as a reference target.

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SHRAPNEL AND CASE-BURSTING SHRAPNEL.

187. Height of burst is the angle in mils, in the vertical plane between the burst and the target. The normal height of burst is that which is the most effective; it is equal to—

4 millimeters for guns, with full service charges.
8 millimeters for howitzers, with full service charges.
8 millimeters for guns, with charges 2 and 3 (charge 1 for the 95-millimeter gun).
12 millimeters, with other charges.
20 millimeters in vertical fire.

Projectiles containing heavy balls and using plunging fire remain effective for heights of burst greater than the normal. In particular, the 155-millimeter case-bursting shrapnel, thanks to the weight of its balls (416 balls of 25 grs.) and of its fragments (288 fragments of 43 grs.) is effective, even when it is impossible to adjust properly the height of burst. (The terminal velocity of the 25-gr. ball being approximately equal to the killing velocity.) But we must not forget that raising the heights of burst shortens the pattern. (See figures.)

Therefore, we must not hesitate to execute time-fuse fire with the 155 millimeter without adjusting the fuse, beginning with high bursts and modifying the height of burst later by observing the fire. The time-fuse fire executed on moving targets should be opened suddenly and should cover rapidly the entire zone in question.

In general, aside from adjustments, case-bursting shrapnel should not be fired by percussion, since their small charge makes them ineffective.

The keeping of the fuses in separate lots is very important. The same fire should be executed with fuses of the same lot. Fuses should not be uncapped until the moment of setting. Projectiles whose fuses have had their caps removed are sent back to the park.

The fuse setter permits of great regularity in setting a fuse.

ADJUSTMENT OF THE FUSE.

188. *Determination of the initial fuse setting.*—Let the deflection and the range of the moment be known either by percussion adjustment, or by transfer of fire, or merely from the range table corrected for the corrections of the moment.

In the table take the fuse corresponding to the range of the moment. This fuse is the initial one.[1]

[1] The old range tables give the fuse to be set, that is, the fuse which, under normal conditions, will give the normal height of burst. Certain new tables give only the time of flight, which generally differs but little from the fuse to be set.

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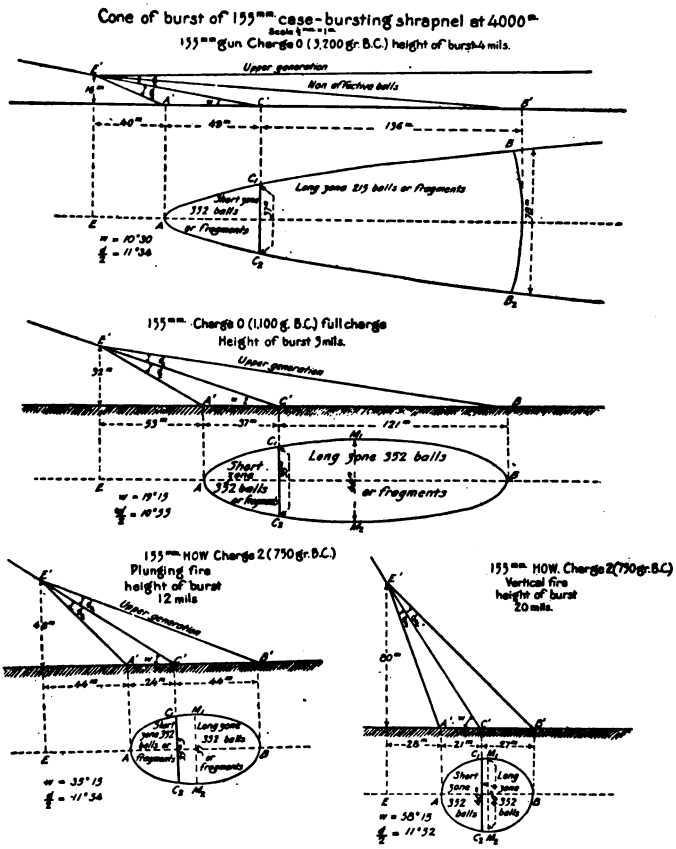
If the altitude of the battery exceeds 500 meters, this initial fuse is corrected in accordance with Table VII, combustion being slower in rarified air (likewise, in cold and damp weather, combustion is delayed).

Fig. 47



We proceed by a series of four observed rounds. Nevertheless, if the first two rounds observed are very high or graze, we stop the series and make a correction of four-tenths of a second in the proper sense.

We fire by platoon salvos. The corresponding commands are: "Right, right, correction so much, so many degrees."

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The fuse is considered as adjusted, and takes the name of *adjustment fuse*, when, in a series of four rounds, the number of high bursts is equal to the number of low ones.

After a series which has not given this result, the fuse must be corrected by as many times one-tenth of a second as there are rounds to be changed from one sensing to the other to obtain an equality of high and low bursts.

The bursts at the proper height are considered, half of them as high and the other half as low. Graze bursts are considered low, unless there is reason to suppose that the fuse has been incompletely set (for example, in a series whose other rounds are very high).

The setting of the fuse is corrected only when two consecutive series show the need of it.

If in the course of adjustment we are led to make a correction equal to or greater than the preceding one, we take an intermediary fuse.

When the fuse setter is used, the rules are the same, each division of the corrector corresponding to an interval of one-tenth of a second.

Increase in time of flight is effected by lowering of the corrector, and inversely. With the corrector 20, the graduations of the fuse setter and of the fuse coincide.

FIRE FOR EFFECT.

189. The surface to be covered is divided into sectors of 5 decigrades up to 4,000 meters, 3 decigrades up to 6,000, and 2 decigrades beyond that. It is also divided into zones of one-half fourchettes up to 4,000 meters, and one-fourth fourchette beyond that.

To keep the height of burst constant, the fuse is corrected concurrently with the range, with the aid of the range tables.

Remarks.—(1) In vertical fire, to reach a target behind a covering crest, we must adjust our percussion fire with respect to the crest, transfer this fire to the target, adjust the fuse to 20 mils above the crest, and increase the time of flight by as many times one-tenth of a second as there are mils between the covering crest and the target.

(2) All time-fuse fire, whose adjustment in range is one-half a fourchette too long, is of little or no effect.

(3) Against unsheltered personnel, time-fuse fire is effective even when one-half a fourchette too short.

(4) It is therefore well to execute time-fuse fire with a fairly short trajectory, rather than with a mean trajectory corresponding to the target. It is absolutely disadvantageous to use a long trajectory against troops in the open.

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(5) The adjustment in range must be very accurate against sheltered personnel. Moreover, the greater the angle of fall, and for the same range, the smaller the charge, the greater must be the accuracy of the range adjustment in time-fuse fire.

(6) For time-fuse fire against unsheltered troops we always use the heaviest charges.

(7) In time-fuse zone fire, the greater the angle of fall the smaller must be the jumps in range.

TIME-FUSE FIRE WITH SHELL.

190. *Calibers 95-mm., 105-mm., 120-mm., and 155-mm. gun.*—The maximum effectiveness is obtained when the shell bursts at a height of 20 meters, no matter what the range may be. It is slightly diminished when the shell bursts lower, between 20 and 6 meters. It diminishes progressively when the height of burst rises above 20 meters, and becomes almost 0 at 80 meters.

Since the steel-coated cast-iron shell is more effective than the steel shell, it should usually be employed.

It is assumed that the sheaf of the time-fuse shell of the 155-mm. gun bursting at a fair height covers a front of 100 meters; the central part of this sheaf (width 60 meters) is very deadly.

The effects of the 95-mm., 105-mm., 120-mm. shells are intermediate between those of the 75 mm. and the 155 mm.

To cover a front of 100 meters (narrow target), the necessary expenditure in ammunition is approximately as follows:

Twenty 155-mm. shells, thirty 120 mm., thirty-five 105 mm., forty 95 mm.

ADJUSTMENT BY HIGH BURSTS.

191. This adjustment is employed when the target does not lend itself to adjustment by percussion rounds; for example, in firing on a village square when only the tip of the belfry is visible above the trees.

It demands bilateral observation; whenever possible, combined observation.

The problem is to determine a trajectory such as PH, BH being a height favorable to observation.

The adjustment is conducted as in ordinary fuse adjustments until the height BH is obtained. The burst is then shifted in range, so as to bracket the target within 4 or 2 fourchettes, according to the position of the lateral observer. For this purpose we determine, with the aid of the tables, the fourchette in time of flight corresponding to the fourchette in quadrant elevation, and each correc-

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tion in range is accompanied by a corresponding correction in time of flight.

We take the mean time of flight and quadrant elevation of the bracket, and reduce this quadrant elevation to HPB. This gives the trajectory of PB. It only remains to reduce the time of flight obtained to 0.4 second to obtain effective bursts.

When it is impossible to reduce the bracket, fire for effect is executed on the zone of the bracket.

Fig. 48

If the target is a captive balloon, it is frequently possible to observe the fire from the battery. The following method may then be adopted:

Lay the two extreme pieces directly on the target and fire by salvos at intervals of about 1 second. If the bursts are disposed in the same order as the guns, the salvo is short; if they are disposed in the inverse order, the salvo is over.

The 105-mm. gun has tracer shells, making it possible to employ ordinary methods for fire on balloons.

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PART V.

RECONNAISSANCES AND INSTALLATIONS.

CHAPTER XIII.

Choice of a Battery Position.

192. *General remarks.*—Battery positions are determined by the tactical mission. Positions for batteries using curved fire are determined by the necessity for favorable fire on the advance position of the enemy and his rear terrain communications. Their zone of action should be as extensive as possible. Positions for gun batteries are determined by the necessity for reading even the most remote of the enemy's batteries, always keeping the fire echelonned in depth. Thus we are often lead to have batteries of this kind on a level with the Field Artillery, and often in front of it.

193. *Definitions.*—

Covering mass is an undulation of the terrain whose upper part is called the crest.

The word *mask* is used for the hedges, lines of trees, walls, houses, embankments, etc., and all objects located on the ground.

The word *cover* is usually reserved for terrain in which the vegetation may conceal the matériel and works from airplanes.

A battery placed behind a crest or mask is said to be defiladed with respect to a point when it can not be seen from that point.

The plane of defilade is the plane passing through the covering

Fig. 49

crest C (or the mask) and the danger point P from which it is necessary to be defiladed.

PROBLEMS TO BE SOLVED IN THE RECONNAISSANCE.

194. The different problems presented are:

(1) *The zone*, of varying width, imposed by the commanding officer.

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(2) *The accessibility* for the matériel and the supplies, very important problem for most of the heavy artillery matériel.

As soon as we get off the roads, the narrow-gauge railroad must be used for supplies. A small section of light track (called a spur) may however be sufficient to unite the battery with an intermediate depot constructed on the side of a neighboring road.

(3) *The nature of the soil*, which facilitates excavation more or less. Sometimes it is necessary to dig an experimental hole in the ground and to study a method of draining off the water. An effort should be made to post the pieces according to the natural contour of the terrain. We must avoid making a parados in hard soil, which might produce effective rear sheaves. We establish a first rapid plan for the work to be done, taking into consideration the time, personnel, and tools required, and verifying at once that they conform to the conditions imposed by the commanding officer.

(4) *The visibility to airplanes.*—The signs indicating batteries on aerial photographs are the necessary excavations in the work of construction and the tracks leading to the batteries. It is therefore advisable to choose positions on the side of a road or of an old and rather wide track in the woods (preferably in a small forest, to avoid having to cut down trees) in former infantry positions, in ruined villages, in quarries, and in village orchards.

(5) *The maximum defilade compatible with the mission.*—This problem (very important for field artillery) is usually presented to the heavy artillery only in the form of a verification, thanks to the readiness with which almost all heavy matériel fires at high angles and with reduced charges. Nevertheless certain matériel uses only a small number of reduced charges—the 105 mm. has but one charge and the 95 mm. but two. Moreover, certain projectiles should be fired with only a small number of reduced charges. (See Note I, below.) Finally, certain missions may demand the use of flat trajectories (for example, fire on a vertical target), for the probable error in height diminishes as the initial velocity increases. (See Note II, below.) It may also be necessary to have a high horizontal component of the terminal velocity, either to produce the effect of shock or that of surprise on personnel.

NOTE I.—For example, the steel-covered cast-iron shell used for the 155-mm. gun is usually furnished only with the charge 00 (4.710 kg. BG_5), which is susceptible of only one reduction (4.05 kg.). As it often constitutes a large part of the supply, it is well either to consider this in the reconnaissance or else to assure ourselves that we have charges 1 (2.4 kg. BC) on hand.

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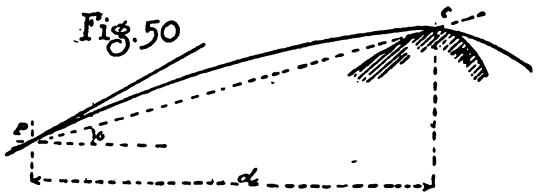
Let α be the elevation corresponding to the range to the crest or the mask, and σ be the angle of site in degrees to the summit of the crest or mask.

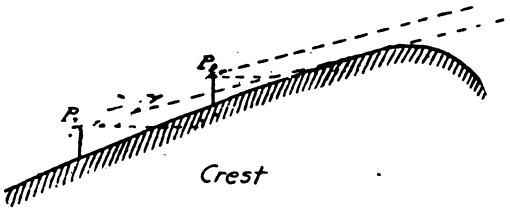


We should have:

$$A > \alpha + \sigma \text{ or } \sigma < A - \alpha$$

Measure σ with the sitometer, or with a glass and level, or with a theodolite.[1]

We must always keep a certain factor of safety necessary for the adjustment; it is especially important to hold the apparatus at a



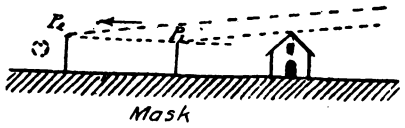


Fig. 52

height above the ground less than (or at most, equal to) the height of the trunnions above the ground. If σ is found to be too large, we must go farther up the slope, or farther from the mask.

[1] Complementary correction for site must be made when α and σ are fairly large ($\alpha > 10°$ and $\sigma > 10$ mils). For example, in mountainous country we are constantly called on to fire beyond high and distant crests; while in undulating country there is frequently a second crest which the trajectory must cross. Likewise, in firing over a plateau, the far edge of the plateau constitutes a second crest. Passage over all the crests must therefore be verified. For these successive crests, d is frequently large enough to require a complementary correction for site.

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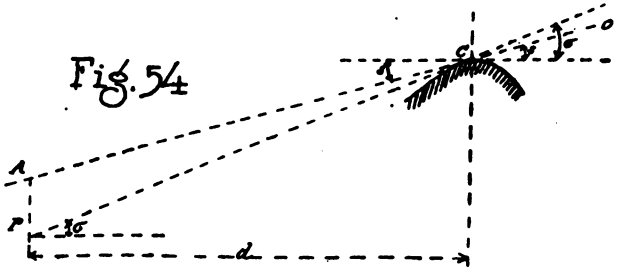
THIRD PROBLEM.

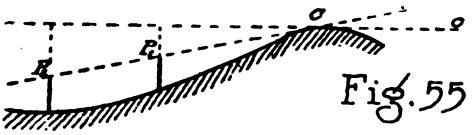
197. *To calculate the defilade in meters with respect to an enemy observation station at O.*

The defilade is the height PA, A being the point at which the vertical line drawn through P intersects the plane of defilade, from which we obtain $PA=d\ (\sigma-s)$, s being the angle of site of O from the crest; it is measured by the sitometer. In case of a mask, the



summit is not often attainable, nor even its base. We take from the map the difference in altitude between the summit and the point O, and from it obtain s by the formula $m=\frac{f}{d}$.

Remark.—As a result of the change of slope in the ordinary terrain, the defilade of P_2 is evidently greater than that of P_1. Moreover, the dead angle is less for P_2. On the other hand, P_2 is liable to be located on moist ground, and the dispersion of the enemy's fire is very apt to be less at P_2 than at P_1. Finally, at the bottom



of a valley, as at P_2, gases readily accumulate. All these points must be considered.

This third problem is of interest in determining whether the battery is defiladed against flashes, smoke, and dust. Flash defilade, for matériel of average caliber, is about 8 meters; for guns firing at high angles, with heavy charge of slow powder, it is between 15 and 20 meters.

Remark.—Problems 1 and 3 can be solved satisfactorily without any other instrument than a sitometer.

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198. *We measure the space available and mark the first approximate starting out of the direction of fire and of the front.*—When the terrain permits it, it is well to employ large intervals (30-meter between pieces) to localize the effect of enemy shells, and to reserve space for the construction of shelters and magazines. In forming the sheaf it is well to have these intervals regular.

The front may be oblique to the line of fire, but the intervals must then be increased. If the obliquity is too great, the service of one piece may be interfered with by the fire of the piece behind it.

The axial line of fire should be determined most accurately by a regular topographical operation. The horizontal field of fire in certain heavy matériel is very small. The total horizontal fields of fire are as follows:

155-mm. howitzer, 1881–1912	24°
220-mm. mortar	40°
270-mm. siege mortar	30°
270-mm. mortar	12°
280-mm. mortar	20°

Moreover, it is always very difficult to shift a piece already posted.

In the course of the reconnaissance we should content ourselves with a rapid determination of the axial line of fire on the map or marked out on the ground to verify that the front may be traced with an obliquity compatable to this axial line of fire.

RELATIVE VALUE OF THE PROBLEMS PRESENTED.

I. DEFILADE.

199. Verifying the possibility of carrying out the mission is of the utmost importance. The defilade must be arranged as well as possible, but first of all the mission must be fulfilled.

II. COVER.

The attempt to find cover from aerial view is not so important in an attacking division in which our pursuit airplanes and our counter-battering artillery prove their superiority. On the other hand, in a defensive sector, letting the enemy see an occupied battery or an ammunition depot would be playing into his hands.

III. ACCESSIBILITY.

This is a very important consideration in an attacking sector in which the battery should be able to receive large quantities of ammunition in a very short time and be capable of executing a rapid advance.

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On the other hand, in a defensive sector, the time and labor required for repairing the approaches or laying a narrow-guage track are generally available.

Chapter XIV.

Choice of an Observation Station.

200. Locating observation stations is a very important operation, one which should be undertaken as soon as the mission is known.

Even when an airplane is constantly available, it is well to locate one or more terrestrial observation stations, facilitating the formation of the sheaf and aiding adjustment on a reference target. Terrestrial observation stations, although sometimes available only under unusual circumstances, should be very carefully located on account of their great efficiency. They allow continual observation day and night with perfected sighting apparatus, and are independent of atmospheric conditions.

A battery observation station should possess the following two essential qualities:

(1) A good view of the target.

(2) Sure communication with the battery.

The better the observer sees the terrain around, and especially behind the target, the more certain and rapid the adjustment.

There is the greatest advantage in not being forced to change position in observing different points fired on in the same zone of targets; that is why elevated points, even when distant, are preferable.

201. We must distinguish between distant observation stations, which observe from considerable distances and are usually located near the batteries, and advanced observation stations, which observe at short range and are at considerable distances from the batteries.

Distant observation stations—Advantages.—More extensive field of view, easier connections with the battery, smaller distance between the officer and his command.

Defects.—Necessity for powerful optical apparatus, impossibility of adjustment on most of the closer elements of the enemy.

Advanced observation stations—Advantages.—Possibility of exact adjustment on the enemy's first line, liaison with the infantry, moral support brought to the infantry.

Defects.—Small field of view, lack of commanding positions, difficulties of observation under bombardment, difficulties of liaison with the battery.

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202. An axial observation station is desirable for the following reasons:

(1) It facilitates the observation by the battery of its sector. Since the possible observation stations are not often numerous, the choice of the axial line of the sector of fire usually depends on the location of the observation station, and should lie in the neighborhood of the line joining the battery to the observation station so that the observation will be really axial.

(2) It makes possible combined observations, which are the best. When we can not observe from the neighborhood of the battery, axial observation demands a large number of observation stations when the field of fire is extensive. Lateral observation should therefore be frequent. The position of a lateral observation station should be very accurately located in order to be able to determine the fourchette in direction.

The following is a good location:

An observation station near the battery, and consequently sufficiently axial, enables us to observe a large part of the field of fire, to make a first adjustment in direction, to verify the sheaf, and to make adjustments on auxiliary and reference targets. It is called a *battery observation station*. It is occupied constantly, night and day, and is always ready to receive optical and acoustical signals from the front. Its liaisons with the battery are readily made, since the distance between them is short. It is also charged with signaling that the enemy's balloons and airplanes are coming from the front. A small station near the battery should be instructed to signal the approach of hostile planes from the rear. The observers should be provided with field glasses and silhouette books. One of them should be a trumpeter who should give one short blast to signal the approach of the airplane, two short blasts to signal the withdrawal of the airplane, and three short blasts to signal the disappearance of the airplane.

One or more lateral observation stations, occupied when the situation demands it, complete the system for adjustment on certain targets.

A single observation station is not usually sufficient to accomplish several missions.

203. *Observing personnel.*—We now come to multiple observation stations. The battery commander should therefore appoint at least two noncommissioned officers and four gunners as observers and two lookouts for airplanes (usually two trumpeters), who should all be familiar with the use of the telephone and the Morse code.

Organization of the observation stations.—Observation stations should be camouflaged with the greatest care, especially during their

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balloon and airplane observers who are working in connection with his battery; these observers themselves have a right to visit him in his battery.

He should study aerial photographs, which often assist him in locating targets and controlling his fire by examination of the points of impact.

He should keep up to date his map and list of enemy's batteries with the map and list established in accordance with the daily information bulletins (which he receives from the Information Service of the Artillery).

Finally, the battery commander is sometimes led to appeal to battalion or command observation stations of possible use to him, especially the observation stations with a view over a possible zone of fire, and he should not hesitate to give orders necessary to improve telephonic connections with them.

CHAPTER XV.

Construction of the Battery.

(Paragraphs 206 to 221 omitted. Covered in "Organization and Construction of Battery Emplacement.")

CHAPTER XVI.

Liaisons.

222. The following liaisons are of capital importance and should be established:

1. Between the battery and the observation stations.
2. Between the battery and the command post.
3. Between the command post and the battalion commander's command post.

They should be established in the following manner:

223. *Insulated cable telephone line.*—Double lines for the advanced observation stations, in order to prevent deflections through the earth and avoid the possibility of messages being picked up by the enemy when the distances are small. Single-wire lines are absolutely forbidden unless at a distance of at least 1,000 meters from the enemy.

(*a*) Laid out on small stakes along a narrow ditch whose cross section should be spade shaped, or fastened to the sides of the communication trenches with small hooks. Take care to protect the

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edges of the ditch with a small wire fence and prepare proper crossings.

(*b*) Along an itinerary familiar to repair squads and planned in advance, avoiding places under fire.

(*c*) Marked at frequent intervals with small wooden tags bearing proper identification.

(*d*) Passing under roads in leaded cables or at least 3 meters above ground.

(*e*) Periodical testing several times a day.

(*f*) Immediate repairing by two parties, each starting from the opposite end. The "central" party consists of two telephone operators, with the "testing instrument" and the repair tool kit; the other party consists of the second observer only (the first remaining at his post with the instrument).

NOTE.—Telephone wires require intelligent care and interest. Every noncommissioned officer should carry a few clips or hooks in his pocket, in order to be able to fasten or clear away temporarily any fallen wire which he might run across.

224. *Visual communications.*—With lanterns or signal-light projectors, or flags, always at hand to replace the wire. They should be frequently tried out. The post of the light projector should be bombproof, and, if necessary, fitted with a periscope, so as to be practicable during a bombardment.

In some cases these two means of communications may be reenforced by sound signals or wireless.

Knowledge of the Morse code is important, as it permits visual, sound, and wireless signals to be made. Relay of agents (couriers and runners) should also be provided.

Liaisons must operate at all times. The fact that mechanical means have defaulted under certain conditions will never excuse a commander of remaining in ignorance of the situation of his unit and not being able to exercise the necessary personal direction over it.

CHAPTER XVII.

Preparation For An Advance.

225. *Advancing the observation station.*—The first advance movement is frequently made by the observation station. Preparation should include:

(*a*) A careful map study of the terrain in front of the O. S., in order to simplify the reconnaissances to be made on the conquered terrain.

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Cross sections of the terrain should be made with a view to discovering the various dead angles of the proposed observation stations, taking the variable contours of woods and villages into consideration.

(*b*) A study of the routes of the new telephone liaisons and the positions of visual signal stations.

(*c*) Provision, as well as transportation of the material for constructing the lines, the observation stations, and the command posts.

228. *Advancing the battery—*

(*a*) Maintenance of the loading ramps in condition for a rapid evacuation of the battery.

(*b*) Preparation of the material necessary to repair the roads.

(*c*) Reconnaissances of advanced positions on this side of and near the first line which the battery might be called upon to occupy, and especially reconnaissances of the routes to be taken. Some of these positions might even be arranged during the preparatory period. (Heavy batteries may be required to use field artillery shelters, and in such cases careful note should be made of the capacity of the shelters and the changes to be made before storing ammunition therein.)

(*d*) Detailed study of the measures required to assure communication by telephone or, temporarily, by any other means, and the continued cooperation and liaison of the Artillery with the Aerial Observers.

(*e*) The bringing up of ammunition must also be organized in every detail.

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PART VI.

CARE OF MATÉRIEL AND AMMUNITION.

CHAPTER XVIII.

Care of Matériel.

227. As this subject is treated in detail in the school courses, only the fundamental principles will be mentioned here.

(*a*) The care of the matériel is confided to an officer. The chief mechanic is under his direct orders. This care includes not merely the daily care, but as thorough a cleaning and examination between firing as is possible, beside putting each gun in turn out of action for a whole day in order to dismount, inspect, clean and oil it thoroughly.

(*b*) Every officer liable to be called upon to act as battery commander should be able to recognize either during fire or during an inspection, any injury to the gun, to appreciate its gravity and direct the necessary remedies or prevent a recurrence. He must be able, in particular, to distinguish between repairs requiring the matériel to be sent to the repair shops and those which can be made by the battery workmen.

(*c*) The gunner is always present when his piece is to be inspected or dismounted. He makes a note in his "piece note book" of the dates and result of the inspections. This notebook, kept in the form of a journal, also contains the number of rounds fired each day, with the charges used, and the number of kilometers covered, etc. In a word, it contains the history of the piece.

CHAPTER XIX.

Care of Ammunition.

228. *General Remarks.*—Ammunition should be the object of very careful attention and frequent supervision by artillery officers of every rank.

Battery commanders, in particular, are obliged to make a daily and very minute inspection of their ammunition depots, and have made without delay any improvements which appear necessary.

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It is expressly and absolutely forbidden to leave ammunition in the open air. Powders, projectiles, and fuses must be stored.

229. *Powders.*—Cases must be kept cool. Never leave a metal case in the sun. In order to avoid abnormal pressure in the guns during periods of great heat, it is extremely important to take precautions against the heating of the ammunition, and especially to shelter it from the direct rays of the sun.

When batteries are not in action, the ammunition which is not stored in shelters should be covered with canvas or a thick layer of branches. The canvas should be supported, so as to allow the free circulation of air between it and the ammunition. It is well to remember that certain canvas covers, especially when camoufled with ordinary paint, are very inflammable.

Open and close the cases without injuring the water tight jointures. Use the nonwaterproof cases first, then the oldest powders. Lay the cases on their sides, in order to prevent water standing on the lid. Put the powder from modified charges back into their corresponding cases and mark them. Do not open the cases for investigation inside damp shelters or in damp weather. Store each part of the same lot under identical conditions.

230. *Projectiles.*—Whenever possible stand the projectiles on end, on boards. If for lack of space they have to be stored in layers put boards or clean branches in between them, so as to prevent the bands touching. Restrict the number of superimposed layers (three for medium caliber). The ogive must always face the accessible side.

Wipe the outer surface carefully and avoid scratching the paint. The bands should be protected as well as possible during transportation. Remove burrs or roughness with a soft file. Do not grease them in advance, unless they are sheltered from dust. Oil the swell (shoulder) slightly.

Replace any missing casing plugs with some spare retained plugs. Return all the other plugs to the park.

No shells equipped with relayed fuse containers should ever be fused in advance. In case a projectile has been fused but not fired, the fuse should be unscrewed and the container plugged again. Combination fuses and supersensitive (I. A.) fuses, Model 1915, should remain capped until the moment of firing.

Shrapnel or case bursting shrapnel, whose combination fuses have been prematurely uncapped, should be fired soon, and therefore should be stored in depots in such a way as to be used first. *Supersensitive (I. A.) fuses, Model 1915, which have been uncapped should not be used under any circumstances.*

The following precautions should be observed in storing special shells (gas, etc.).

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233. II. *Supersensitive percussion detonator fuse 24/31, Model 1915 (I. A.).*

(*a*) Priming—

Screw the fuse in by hand by turning the cylindrical body. Then uncap the fuse by pulling the ribbon off.

(*b*) Observation—

1. When the fuse is uncapped do not touch any uncovered portion, especially the brass spirals.

2. After the fire, if a projectile primed with an uncapped fuse remains unfired, unscrew the fuse and put it aside to be sent back to the park. Such uncapped fuses should never be used again to arm a projectile.

3. To unload the piece, interpose a wooden sleeve 30 centimeters long between the rammer and the projectile. This sleeve should have the exterior and interior diameters of the rammer head for that piece.

4. Supersensitive (I. A.) fuses, Model 1915, with red heads should only be fired in 155-mm. howitzers, Model 1881–1912; the 1890 and 1904 rapid firers; and in guns with left-hand twist rifling (95 mm., 100 mm., and 16 cm.).

5. Supersensitive (I. A.) fuses, Model 1915, with unpainted heads should be reserved for the other guns of 155 mm. and below.

Charges with which the following fuses can be used:

Calibers.	1899–1915, long delay.	1899–1908, short delay.	1899, non-delay.	1914, instantaneous.	I. A. 1915 or I. A. L. 1916.	Combination detonator fuse 24/31, Model 1916, or long time, Model 1917.	Combination fuse 30/55, Model 1889.
95	0,1	0,1	0,1	0,1	0,1	.....	.....
120 gun	00, 0, 1, 2, 3.	00, 0, 1, 2, 3.	00, 0, 1, 2, 3.	00, 0, 1, 2.	00, 0, 1, 2.	.....	.....
120 howitzer, Model 1890.	0, 1, 2, 3, 4, 5, 6, 7.	0, 1, 2, 3, 4, 5, 6, 7.	0, 1, 2, 3, 4, 5, 6, 7.	0, 1 (BC) and 3 (B C NL).	0, 1, 2, 3, 4, 5, 6, 7.	.....	.....
155 gun	00, 0, 1, 2, 3, 4.	00, 0, 1, 2, 3.	00, 0, 1, 2, 3.	00, 0, 1, 2.	00, 0, 1, 2, 3, 4.	.....	.....
155 howitzer, Model 1881 and Model 1904 R.F.	0, 1, 2, 3, 4, 5, 6, 7.	0, 1, 2, 3.	0, 1, 2, 3.	0, 1	0, 1, 2, 3, 4.	.....	.....
155 howitzer, Model 1915, Schneider.	.....	.....	.....	00, 0, 1, 2.	All the charges.	00, 0, 1, 2, 3.	00, 0, 1, 2, 3.

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ANNEX NO. 1.

TABLE I.

Expenditure of ammunition for the destruction of auxiliary defenses.

Range (meters).	Caliber.	Terrain.	Projectile.	Fuse.	Expenditure for a wire entanglement 30 meters in depth to cut a breach 25 meters in width.
2,000 to 5,000.	155-mm. howitzer.	Steep counter slope.	Shell, shell D.	I. A...	150 A shells } at 2,000 meters. 300 D shells }
					200 A shells } at 3,000 meters. 300 D shells }
					240 A shells } at 4,000 meters. 300 D shells }
5,000 to 7,000.	155-mm. gun or 155-mm. howitzer (Schneider).	Counter slope.	Shell, shell D.	I. A...	250 A shells } at 5,000 meters. 350 D shells }
					300 A shells } at 6,000 meters. 400 D shells }
					350 A shells } at 7,000 meters. 400 D shells }

If the entanglement is made of chevaux de frize, always use delayed-action fuses.

TABLE II.

Expenditure of ammunition to destroy shelters.

Ranges (meters).	Protection of shelter.	Calibers.	Projectiles.	Fuses.	Number of rounds.
2,000 to 4,000...	Medium and strong.	155-mm. howitzer.	Steel shell or cast-iron shell overlaid with steel.	Delayed.	80.
Beyond 4,000...	Medium.....	155-mm. gun..	.....do.....	.....do...	150.

TABLE III.

Expenditure of ammunition for the destruction of trenches.

Ranges (meters).	Calibers.	Projectiles.	Fuses.	Number of rounds.
2,000 to 4,000....	155-mm. howitzer.	Elongated.	Delayed, with 20 per cent nondelayed fired toward the end.	80 to 100 rounds per important point, i. e., 3 or 4 rounds per meter of front (frontal fire) or 1½ rounds per meter (enfilade fire).
5,000 to 7,000...	155-mm. gun or 155-mm. Schneider howitzer.	...do.....	.....do.....	5 to 6 rounds per meter, according to range (frontal fire).

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Manual for the battery commander :
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